Mr. Austin Hobart Clark
with kind regards from
F. A. Bather

TRIASSIC ECHINODERMS OF BAKONY

BY

F. A. BATHER, M. A., D. Sc., F. R. S.

ASSISTANT-KEEPER OF GEOLOGY IN THE BRITISH MUSEUM (NATURAL HISTORY)

WITH EIGHTEEN COLLOTYPE PLATES, AND SIXTY-THREE ILLUSTRATIONS IN THE TEXT.

Separatabdruck aus dem Werke: «Resultate der wissenschaftlichen Erforschung des Balatonsees». I. Band, 1. Teil. Pal. Anhang.

BUDAPEST
DRUCK DER K. U. K. HOFBUCHDRUCKEREI VICTOR HORNYÁNSZKY
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INTRODUCTION.

NEARLY all the fossil remains of Echinoderma described in this memoir belong to the two classes Crinoidea and Echinoidea, of which the Crinoidea are dealt with first. Except for a few crinoid columnals, which come from beds apparently contemporaneous with the Muschelkalk, the fossils appear to be distributed between two horizons, of which the lower seems to contain a fauna generally similar to that of the well-known Cassian Beds (zone of *Trachyceras Aon*), while the upper horizon is not much later in date and may be regarded as Raiblian. These matters, however, will be discussed more fittingly after the material has been described.

The first instalment of these fossils was sent to me by Professor L. DE LÓCZY in April 1901, and further instalments followed in December 1902 and February 1903. For the long time that has elapsed before the completion of this memoir I have frequently had to crave his indulgence. The personal reasons that have contributed to this delay need no mention here, but it may be pointed out that the fragmentary nature of the material has rendered the task far from easy. The mere sorting out and examination under a lens of each of the many thousand minute specimens was in itself a lengthy process. Then, before going far with their determination and description, it was found necessary to examine all the type-specimens, and as much other material as was available, of species previously described from other Triassic localities. We have fortunately an excellent series of St. Cassian fossils, including the main KLIPSTEIN collection, in the British Museum. This has been of the greatest service, especially since it has been sadly neglected by previous writers. The collections of MÜNSTER and others at Munich, those specially examined by LAUBE at the Hofmuseum and the Geologische Reichsanstalt in Vienna, the QUENSTEDT collection at Tübingen, the Zwinger in Dresden, the Museum für Naturkunde in Berlin, and the collections of the Geological

Institute in Budapest, have all been visited for the purposes of this work, and to the authorities and officers of those museums my warmest thanks are here tendered. To incorporate in this memoir all the results obtained from the study of pre-existing collections would have been to depart too far from its professed subject. Those not directly utilised here may perhaps find publication elsewhere.

It will probably be said that, even as it is, this memoir is too long, and that the descriptions might have been condensed with advantage. To this it may be replied: first, that those unwilling to study the descriptions can read the diagnoses, which are short enough; secondly, that previous work suffers from the entire insufficiency of the descriptions when tested by modern needs, as well as from a lack of enlarged and detailed figures. Lists of fossils drawn up in reliance on descriptions and figures have often been used for the determination of horizons, and sometimes for the elucidation of vast tectonic problems. If those lists may be judged by the names of Triassic Echinoderms which they contain, they are seldom of much value. The stratigrapher of to-day cannot hope for sure results without help from the most refined and detailed palaeontological research. For expressing the results of this research a strict terminology is also necessary, and the endeavour to provide this has occasionally led me into discussions that may appear elementary. Certainly that is what they ought to be.

In addition to the purely systematic descriptions of genera and species there are scattered through the memoir observations bearing on morphology and phylogeny. These, as well as the general faunistic and stratigraphical results, are briefly summarized in a concluding chapter. Only one more remark absolutely demands insertion here, and that is an expression of my hearty thanks to Professor L. de Lóczy for entrusting me with these interesting fossils, for his extreme forbearance in the matter of time, and for many acts of kindness to me during the progress of the work. Above all must be mentioned his permission to me to keep for the British Museum the specimens that remain after furnishing a set of originals to the Geological Institute at Budapest.

London, June, 1909.

CRINOIDEA.

With the exception of a patina and a brachial, both from Cserhát (Leitnerhof), the crinoid remains collected consist of over nine thousand stem-fragments, under which term cirri are included. The correct determination of these fossils is a matter of no small difficulty; and this is due first to the nature of the objects themselves, and secondly to the inadequacy of most descriptions hitherto published.

The difficulties connected with the nature of the objects themselves spring from two causes: first, the relatively slight specialisation of stem-structures among Triassic crinoids, and the consequent similarity of the columnals in species, or even genera, that otherwise are quite distinct; secondly, the variability of the columnals in a single species, or perhaps it would be more accurate to say, the differences between the different regions of a stem in the same individual.

The inadequacy of most of the previous descriptions consists, largely, in the absence of detailed measurements, in the small scale of the figures, if indeed figures are given at all, and in a general failure to recognise, or at least to mention, definite features that might otherwise have afforded material for subsequent diagnoses. There is no doubt an inclination to regard the discrimination of species by stem-characters as an almost impossible task, for the reasons given in the preceding paragraph; and it must be confessed that the study of stem-fragments is not inviting. But, since the majority of crinoid remains always will be portions of stems, and since these are in fact among the commonest of fossils, it is as well that some attempt should be made to discriminate between them, and so to give a fresh weapon to the stratigraphist and palaeogeographer. That which P. de Loriol has done for the Jurassic Crinoidea of France should be extended to other ages and other countries.

It is fairly easy to separate the present material into the two old divisions: wheel-stones (*Trochitae,* which in combination form *Entrochi*) and star-stones (*Pentacrini* of Agricola, *Asteriae* of XVIII Century writers). In their further study of such fragments, and especially of the former, geologists seem to have been guided to generic appellations, rather by the ages of the various beds in which they have found them than by any structural peculiarities. Thus, Ordovician *Trochitae* are referred to *Glyptocrinus,* Carboniferous to *Actinocrinus,* Triassic to *Encrinus,* and Jurassic to *Apiocrinus.* In a vague way this procedure finds logical justification in the principle: Entia non sunt multiplicanda praeter necessitatem. Accepting this, we must recognise the existence in Triassic rocks of the following genera: *Encrinus,* *Dadocrinus, Isocrinus,*[1] *Balanocrinus,* and *Millericrinus* (?). Other genera were probably represented in Triassic seas, but we are still ignorant of the forms that we may suppose to have linked the Palaeozoic Monocyclica to the Plicatocrinidae and Hyocrinidae, and we look in vain for ancestors of the Bourgueticrinidae and Eugeniacrinidae. The Apiocrinidae also one would expect to have been represented by more species than the doubtful *Millericrinus recubariensis* (Crema), which, Professor von Koenen suggests to me, may be only a young *Dadocrinus.*

Now this list of probable or possible genera renders it quite impossible for one to refer all Triassic *Trochitae* to *Encrinus,* or all *Asteriae* to *Pentacrinus* (i. e. *Isocrinus*). The *Asteriae,* it is true, being more specialised, can generally be assigned to one or other of the known genera of Pentacrininae, especially when they are associated with cirriferous nodals. Nevertheless, in these early representatives of the Pentacrinidae, the differentiation is not so great as in later forms, and it is hard to say of some specimens whether they are *Isocrinus, Balanocrinus,* or *Holocrinus* (see R. Wagner[2] 1886, «Encriniten des unteren Wellenkalkes»; pl. i., figs 2—6); while isolated columnals of *Dadocrinus* may be either *Trochitae* or *Asteriae* (see H. Kunisch[2] 1883, «Ausgewachsener Zustand von *E. gracilis*»; pl. VIII, figs 6, *a—e*).

If one acts on the principle that all Triassic *Trochitae* should be referred to *Encrinus* until the contrary be proved, there remains the difficulty of assigning them to species. If the recognised species of Muschelkalk *Encrinus* have been rightly separated, then we meet here with distinct species having the same stem-characters. The case is different with the species from the Cassianer-Schichten. Here there is in practice very little difficulty in referring the scattered columnals to what appear to be the three well-defined species *Encrinus cassianus, E. varians,* and *E. granulosus,* while these again are readily distinguished from the Muschelkalk form *E. liliiformis.* It is true that columnals occasionally present themselves which cannot readily be assigned to one of these species; but this difficulty may be due either to their ill-preservation, or to their incomplete development as young or freshly forming surfaces; or it may be that there actually are among the St. Cassian fossils certain species as yet unrecognised. My point is that the bulk of the specimens can be sorted out pretty easily.

The same is the case with the *Entrochi* and *Trochitae* of Veszprém. While there are a few doubtful forms, the majority are capable of classification. Moreover, there is here a repetition of the types of structure that characterise some of the St.-Cassian species, with, however, the quite obvious distinction that the Veszprém specimens are both absolutely smaller and relatively of more delicate ornament. There is, of course, no direct evidence that these columnals belong to *Encrinus;* but this parallelism to well-known species encourages one to refer them to that genus and to give them independent names.

I propose therefore to give the usual generic names to all columnals that can with good reason be referred to existing genera. But there remain specimens of

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[1] To this genus I refer most of the Triassic species hitherto known as *Pentacrinus.* See further, pp. 22 and 30.

[2] Complete references to these and all other authors quoted are given in the «List of Papers and Works referred to», pp. 265—274.

which the relationship is doubtful, and for these I shall, following the example of BEYRICH, adopt the noncommittal term — *Entrochus*.

As regards the application of specific names to such fragments, it seems to me that if our descriptions are to be of practical service to stratigraphers, then they must be accompanied by names. A description without a name is soon lost sight of, whereas a name compels attention until at last it finds its proper position, if only as a synonym.

Terminology. — The terms employed for the columnal characters scarcely need special definition so far as the Encrinidae and earlier Pentacrinidae are concerned. But in dealing with the stem of the Pentacrininae, it has been found necessary to revise and coordinate the terminology. In case of doubt, recourse should be had to the explanations there given (see p. 24 et sqq.).

ENCRINIDAE.

For definition, see BATHER «The Echinoderma» p. 181; vol. III in «Treatise on Zoology» ed. E. R. LANKESTER; 1900.

Encrinus.

1760. *Encrinus* C. F. SCHULZE: Betrachtung der versteinerten Seesterne etc. 4to. Warschau und Dresden, p. 21.

1768 *Helmintholithus Encrinus* (pars) LINNAEUS: Syst Nat., XII, vol. III, p. 169; et *H. Entrochus* (pars)? p. 168, non *Isis Entrocha*, I, p. 1288.

1801. *Encrinus* (pars) LAMARCK: Systême des Animaux sans vertèbres etc. 8vo. Paris, p. 379.

1802. *Encrinites* J. F. BLUMENBACH: Abbild. naturhist. Gegenstände, Heft 6, No. 60.

History of the Genus. — It is strange that authors should, almost universally, ascribe the genus *Encrinus* to LAMARCK; stranger still that they should nearly always prefer to quote the «Histoire Naturelle», dating from 1816, instead of the «Systême», dating from 1801; strangest of all that they should not have recognised that the type of LAMARCK's *Encrinus* is *E. caput-medusae*, which is a synonym of *Isis asteria* LINN. and a well-known member of the Pentacrinidae. BLUMENBACH also (1779) had included this species in *Encrinus*, necessarily as its sole representative among living forms. Fortunately, by accepting the name published by C. F. SCHULZE with excellent figures, we save ourselves from the revolution that adherence to BLUMENBACH and LAMARCK might otherwise entail. It is, however, worth while to remember that those writers were perfectly justified in applying the name *Encrinus* to what most zoologists (whether rightly or wrongly) call a *Pentacrinus*, for AGRICOLA, the inventor of the term *Encrinus*, undoubtedly intended by it a portion of stem composed of *Pentacrini* (the *Asteriae columnares* of later writers)[1]; moreover, among the figures referred to by LINNAEUS as covered by his *Helmintholithus Encrinus*, those of Pentacrinids are quite as prominent as those of the accepted *Encrinus*, while his *Isis Asteria* is defined as «Encrinus capite stellato, etc.» (Syst. Nat. XII, p. 1288).

[1] See QUENSTEDT: Petrefactenk. Deutschlands IV, p 452; 1875. Also BATHER: Pentacrinus: a name and its history; Nat. Sci. XII, pp. 245—256; 1898.

A minor consequence of taking 1816 as the date of LAMARCK's name has been the occasional rejection of *E. liliiformis* LAM. in favour of *E. fossilis* BLUMENBACH (e. g. QUENSTEDT loc. cit. and JAEKEL). BLUMENBACH was, it is true, the first post-Linnean writer to give to this species of *Encrinus* a specific name accompanied by description and figures (1802); but LAMARCK (1801) bases his species on the figures given by J. ELLIS «Essay Nat. Hist. Corallines etc.» 1755, pl. XXXVII, fig. *K*, and by G. W. KNORR «Samml. Merkwürdigkeiten etc.» 1755, pl. XI *a*. ELLIS's figure, though quoted by more than one of his immediate successors, is nothing more than a reversed copy of M. R. ROSINUS «Tentaminis de lithozois ac lithophytis . . . prodromus» 1719, Tab. I, fig. 1, at top left hand of plate. The preference therefore should be given to the splendid specimen of the same species figured by KNORR. The history of this specimen has always been to some extent wrapped in mystery. KNORR, in the explanation to the plate, said that it belonged to a merchant in Halle; J. E I. WALCH (op. cit. II, ii, p. 100; 1769), said that its owner was H. LANGE, professor of mathematics in that town; but neither knew what had become of the fossil on the death of its owner. The question was pointedly raised by J. BECKMANN in a review of KNORR and WALCH's work (Phys.-Ökon. Bibliothek. I, p. 68, footnote; 1770), and WALCH made enquiries which resulted in two distinct stories being told, one by C. F. WILCKENS (Naturforscher, III, p. 209; 1774), the other by G. A. GRÜNDLER of Halle (op. cit. VI, p. 179; 1775). Both tales are mentioned by J. S. MILLER («Nat. Hist. Crinoidea», p. 44; 1821), and QUENSTEDT adopts the locality «Schraplau zwischen Halle und Eisleben» as given by WILCKENS (see «Petrefactenk. Deutschlands», IV, p. 453; 1875). Since, however, it was GRÜNDLER who made the original drawing, his account, which is in other respects the more satisfactory, is the one to be followed. According to this, the specimen was bought for two Reichsthaler in Farrenstädt near Querfurth (not far from Schraplau) by a student named VITIGO, who gave it to his teacher, Prof LANGE. While in the latter's collection it was seen by an apothecary of Nürnberg named BEYER, who gave GRÜNDLER one louis-d'or to paint it, so that KNORR might publish an engraving of it. LANGE afterwards sold the specimen for 3 louis-d'or to Herr von GARTENBERG, and GRÜNDLER believed that it came into the Dresden Cabinet. J. S. MILLER (loc. cit.) thought that he had seen the specimen about the year 1800 «in the collection of the Naturforschenden Gesellschaft at Dantzic»; but Professor H. CONWENTZ, who kindly made a special search at my request, reports that the specimen is not in the Provincial Museum at Dantzic, though the collections of the Naturforschenden Gesellschaft have been incorporated in the Museum. Probably it went to Dresden, and was lost in the fire which destroyed so many other specimens. I have sought it there without success. The specimens figured by SCHULZE also (pl. I, figs 4, 5) were said by him to be in the Kgl. Naturaliensammlung of Dresden, and they likewise are not to be found. But there is no doubt as to the identity of all these specimens with *E. liliiformis* LAM., which, therefore, is the name to be given to the genotype.

The Stem of *Encrinus* is the only part of the animal with which the present work is concerned. It is circular in section as a rule, but subpentagonal and even pentagonal columnals may occur in it; the external surface is unornamented; it bears no cirri; the lumen is relatively small, circular, or pentagonal with angles apparently radial or interradial; the joint-surfaces vary greatly even in different parts of the stem of a single individual, but agree in having ridges radiating from the centre, although these are often supressed or modified in the central region, and may be surrounded at the periphery by a smooth rim. In many forms, and in the young possibly of all, these ridges are subject to pentamerism, which, however, is usually obscured in older columnals. The main lines of this, namely those starting nearest the centre, are radial in position, as shown in KLIPSTEIN (1845) pl. XVIII, fig. 19 *b*, and QUENSTEDT «Petrefactenkunde Deutschlands», pl. CVII, fig. 90 *a*, both said to be *Encrinus varians*, as well as in *E. granulosus*.

Thus it is not easy to distinguish the columnals alone from those of *Dadocrinus* (see KUNISCH, 1883, pl. VIII, f. 6 *a*, *e*), or from ordinary inter-nodals of *Holocrinus* (see WAGNER, 1886, pl. I, figs. 2, 6), or even of *Balanocrinus*. In *Isocrinus* and *Extracrinus* the pentamerism is stronger, while in *Millericrinus* the lumen appears to be wider.

Encrinus cassianus.

(Plate I, figs. 1—9.)

1845. *Flabellocrinites cassianus* A. v. KLIPSTEIN: Geol. Östlich. Alpen, p. 277, pl. XVIII, fig 23 *a*, *b*.
1855. *Encrinites Buchii* H. EMMRICH: Jahrb. geol. Reichsanst. VI, p. 896.
1864. *Encrinus cassianus* G. C. LAUBE: Jahrb. geol. Reichsanst. XIV, p. 405; Verh. geol. Reichsanst. XIV, p. 207.
1865. *Encrinus cassianus* LAUBE. — LAUBE: Denkschr. Akad. Wiss. Wien, Math.-Nat. Cl. XXIV, Abt. 2, p. 267, pl. VIII *a*, fig. 1—6.
1875. *Encrinus cassianus* LAUBE. — F. A. QUENSTEDT: Petrefactenk. Deutschlands, IV, pp. 472, 486, pl. CVII, figs. 8. 9, 103—111, 113, 114 (probably not 112 or 115).

History of the species. — The previous synonymy is given by LAUBE (1865) There is, however, a liability to confusion, since LAUBE, following A. D'ORBIGNY[1], refers KLIPSTEIN's *Flabellocrinites cassianus* to *Encrinus granulosus* MÜNSTER, and regards *E. cassianus* LAUBE as a new conception. The holotype of *Flabellocrinites cassianus* is in the British Museum (75861) and apparently was not examined by either D'ORBIGNY or LAUBE. Sixteen years ago, when labelling the specimens for exhibition, I came to the conclusion that it was a crushed specimen of *E. cassianus* LAUBE, and not of *E. granulosus*.[2] A renewed examination confirms me in this belief. Inspection of KLIPSTEIN's figure, 23 *b*, is alone enough to show that the ridges are much coarser than in *E. granulosus;* the central area resembles that of *E. cassianus* LAUBE, rather than of *E. granulosus;* the concentric rings are not really so clear as in KLIPSTEIN's figure, and the concentric striation of which he speaks is not of the same nature as that in *E. granulosus*, but seems to be the combined effect of shearing and weathering. Other specimens of *E. cassianus* present a somewhat similar appearance; QUENSTEDT's fig. 104 shows ridges of equal length. Whether one should ascribe the species to LAUBE or to KLIPSTEIN is a question of small importance; but if LAUBE regarded KLIPSTEIN's species as an *Encrinus*, then according to modern codes of nomenclature, he should not have given to another species of the genus the same trivial name.

Material from Bakony compared with Types and Topotypes. — Seven fragments (*a*—*g*) from the Cassian beds of Cserhát present a general resemblance to this species, though much smaller than the normal St. Cassian columnals.

[1] Prodrome Paléont. stratigr. I, p. 206; 1850.
[2] See also F. A. BATHER, 1897 «Apiocrinus recubariensis, etc.», p. 121.

As regards their articular surfaces, *b, d, e,* and *g* are of the type figured by LAUBE, pl. VIII *a,* fig. 5 *a*; *a* more like his fig. 5 *h*; *f* like this but smaller and less clearly defined; while in *c* the length of the crenellae is about $^1/_3$ the diameter of the joint-face and there is no rim. The last form resembles some columnals of *Encrinus liliiformis* — for instance fig. 8 η on pl. LIII of GOLDFUSS «Petrefacta Germaniae», — but the crenellae are finer and more numerous. There are in the British Museum similar specimens associated with *E. cassianus* from St. Cassian, and there is one such at Munich among MÜNSTER's original specimens, referred by him to *E. liliiformis.*

There are also from Cserhát five quite small specimens, (*h—l*) which may have belonged to the young of this species. The markings on *h* resemble those of the last mentioned; those on *i* and *k* are more like the rimless normal type; and those on the rest are obscure.

The measurements in millimetres are as follows:

Specimen .	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*
Plate I. Fig. . . .	1	—	2	—	3	—	4	5	6	—	7	—
Diameter . . .	4·5	4·5	4·3	3·75	3·3	2·3	2·1	1·9	1·9	1·5	1·1	0·9
Height. . . .	2·4	1·6	2·7	1·8	3·6	3·25	3	2·75	1·7	1·4	1	1·2
No. of Crenellae .	24	about 20	16	14—16	17	13	about 16	12	14	?	18	?
Length of Crenellae	0·7	0·7	1·3	0·6	0·5	0·5	—	—	—	—	—	—

	Measurements given by LAUBE.			Measurements of MÜNSTER's originals. Beiträge IV, pl. V, f. 1.			
				a	*b*	*c*	*e*
Diameter . .	9·0	8·0	5·5	12·5	11·5	10	6·4
Height.	8·0	5·0	4·0	—	—	—	—
No. of Crenellae .	—	—	—	22	21	22	20

MÜNSTER's figures 1 *a, b, e* are, it will be observed, not quite correct.

LAUBE's figures show 25, 26, and 31 crenellae in columnals of uncertain diameter, 24 in a columnal of 11·5 mm. diameter, 33 in one of 10·5 mm. diameter, 22 in columnals of 10 and 6·75 mm. diameter.

Relations of the specimens from Bakony. — Had the normal *E. cassianus* occurred at Cserhát, it is hardly likely that it would have escaped observation. Therefore one cannot regard all these specimens as merely young, nor indeed do *a—e* present the appearance of young in other respects. They may have belonged to individuals dwarfed by local conditions, or they may represent a genuine variety with smallness as a transmissible character. Their rarity suggests the former as the more probable explanation, and this is why I do not propose for them any distinct name. A very similar columnal is to be seen on a fragment of Hallstätter Kalk from Steinbergkogel, in the Hofmuseum at Vienna.

As regards the smaller specimens, *h—l,* one should not overlook the possibility that some or all of them may belong to *Dadocrinus.* The joint-face of *h* is intermediate between KUNISCH, 1883, tab. cit. f. 6 *a* and *b*; that of *i* is like KUNISCH, f. 6 *c,* but has fewer crenellae; that of *k* however is like the normal *E. cassianus* in everything except size.

Note on additional specimens. — Professor LACZKÓ has lately forwarded some material from Veszprém (Giricses-domb, lower stratified limestone), in which are two trochitae (*m* and *n*) generally resembling the specimens *h*—*l*, but with distinctly concave side-faces. The measurements in millimetres are as follows:

Specimen	*m*	*n*
Plate I, Fig. . . .	8	9
Diameter { least . .	1·6	1·0
Diameter { greatest .	1·8	1·2
Height	1·5	2·3
No. of crenellae .	18—20	15
Length of crenellae .	0·5	0·4

There is no rim; the crenellae have not the peculiar notched appearance that characterises *Dadocrinus;* they show signs of arrangement in five groups. It is possible that the longer of the two trochitae is really compound, as described for *Encrinus* by GOLDFUSS (Petrefacta Germ. p. 178) and for *Holocrinus* by R. WAGNER (Jena. Zeitschr. XX, p. 8; 1886).

Encrinus granulosus.

(Plate I, fig. 10.)

1834. *Apiocrinites ? granulosus* MÜNSTER: Neues Jahrb. f. Mineral. 1834, p. 8.

1841. *Encrinus granulosus* (MÜNST.). — MÜNSTER: Beitr. z. Petrefactenk. IV, p. 53, pl. V. figs. 11–19.

1845. *Encrinites granulosus* MÜNST. — A. v. KLIPSTEIN: Geol. Östlich. Alpen. p. 276, pl. XVIII, figs. 20—22,

1865. *Encrinus granulosus* MÜNST. — G. C. LAUBE: Denkschr. Akad. Wiss. Wien. Math.-Nat. Cl. XXIV, Abt. 2, p. 271, pl. VIII *a*, figs. 7—12.

1875. *Encrinus granulosus* MÜNST. — F. A. QUENSTEDT: Petrefactenk. Deutschlands, IV, p. 485, pl. CVII, figs. 91, 96, 97.

1875. *Encrinus* cf. *silesiacus* F. A. QUENSTEDT: Petrefactenk. Deutschlands, IV, p. 486, pl. CVII. figs. 98—101 (? 102).

1889. non *Encrinus granulosus* MÜNST. — S. v. WÖHRMANN: Jahrb. Geol. Reichsanst. Wien, XXXIX, p. 191, pl. V, fig. 8.

History of the species. — The previous synonymy is given by LAUBE, but, as explained above, I do not accept his inclusion of *Flabellocrinites cassianus.*

Judged from the figures alone, the specimens represented in LAUBE, pl. VIII *a*, fig. 10, *c*, *d*, *e*, appeared to me doubtful. This was only because they were badly drawn. They really are quite normal, of the type of the proximal region of the stem. The closure of the grooves to form the canals, seen in these and similar specimens, is the first stage in the evolution of the so-called *Traumatocrinus*, which has a joint-face in other respects closely resembling that of this type of columnal.

The columnals referred to *E. granulosus* by S. von WÖHRMANN (1889) differ from this species in the heterotomous branching of the striae, which are not granular, and are much finer than in *E. granulosus.*

QUENSTEDT (1875) sought to separate from this species those columnals in which the ridges are relatively fine and almost reach the central canal. He compared them to *Entrochus silesiacus.* To this course there are two objections: first, as BEYRICH pointed out (Crin. d. Muschelkalks; Abh. Akad. Wiss. Berlin, 1857, Phys. Kl. No. 1,

p. 46; 1858), joint-surfaces of *E. silesiacus* «unterscheiden sich von *E. granulosus* durch das Fehlen der Körnelung auf ihren .... Gelenkstrahlen». Other differences are the wider lumen and characteristic grooving of the ridges in *E. silesiacus.* Secondly, a careful search through a large number of columnals of *E. granulosus* from St. Cassian, in the British Museum and elsewhere, has brought to light enough intermediate forms to prove the connection of the two types of structure distinguished by QUENSTEDT. It appears that the type which he regarded as *E. granulosus* is found in the proximal region of the stem, that the granules gradually run together into ridges, and that these increase in number in older columnals, that the central star with its five main ridge-pairs occupies a less proportion of the surface and is gradually blurred till at last no trace of it can be detected; and then we have the type which QUENSTEDT called *E.* cf. *silesiacus.*[1] It is, I think, in the distal region of the stem that the radiating ridges again break up towards the centre into coarser granules, often anastomosing in a rough concentric arrangement, while the central area itself is just a slightly roughened plateau. Such a specimen is the original of QUENSTEDT's fig. 101.

Material from Bakony. — To the last mentioned type of columnal I refer with some doubt a fragment from the Cassian beds of Cserhát, consisting of four columnals: diameter 6·35 mm.; total height, 6 mm.; average height of a columnal, 1·5 mm.

Side-faces of columnals very slightly convex.

Joint-face: — lumen, pentagonal. minute, about 3 mm. diameter; central area irregular and indefinite in outline, slightly rough adcentrally, becoming more warty as it approaches the periphery, the warts finally merging into the peripheral crenellae. Neither a radiating nor a concentric arrangement of warts, such as are usual in the normal *E. granulosus,* can be seen clearly, but this may be due to the rather ill preservation of the surfaces. Crenellae number 46, length about 1 mm., width about 2 mm.; clearly visible at the sutures; there is even a tendency for slight ridges to pass from them down the sides of the columnals.

Relations of the specimen from Bakony. — Columnals of *E. granulosus* from St. Cassian of similar diameter have about the same number of crenellae, but the length of the crenellae is greater: e. g. a specimen 5·9 mm. diameter has 35 crenellae, 1·6 mm. long; one 6·8 mm. diameter has 42 crenellae, 2 mm. long. MÜNSTER's pl. V. fig. 12, which, of all his figures, is probably the nearest to our specimen, with a diameter of 6·5 mm., has 42 crenellae, the shorter among which appear to have been less than 1 mm. long. There is, among MÜNSTER's type-material, a specimen still more like ours: Diameter 5·25 mm., height, 1 mm., crenellae 32 or 33, and about 1 mm. long. These details harmonise with the reference of our specimen to *E. granulosus;* but here again, it is remarkable that only one fragment should have been found.

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[1] The original of QUENSTEDT's fig. 102 is less like the normal *E. granulosus:* the striae run to the centre, are coarser than ordinary, and quite obscurely granular; the crenellae are not clearly seen on the suture because of its depression. The 4 columnals uppermost in the figure, and to a less degree the 5th, have concave side-faces and slightly beaded margins. The 3 lower columnals have convex side-faces.

Encrinus cancellistriatus n. sp.

(Plate I, figs. 11—22.)

D i a g n o s i s. — Entrochi with straight side-faces, and of small diameter (1—4 mm.). Joint-faces with small roughened central area, from which radiate fine ridges, increasing by dichotomy or intercalation, and composed of concresced granules with a concentric arrangement varying in distinctness.

M a t e r i a l. — To this are referred 52 fragments from the Cassian beds of Cserhát, 2 from bed e of Section VI, Veszprém and 6 from Veszprém, Giricses domb, of which 2 are from the lower stratified limestone. The original of fig. 13, from Cserhát, is selected as holotype.

D e s c r i p t i o n o f s p e c i m e n s. — The longest entrochus consists of seven columnals. Others consist of from 2 to 4, but most of the specimens are isolated trochitae.

Side-faces of entrochi straight; side-faces of columnals have a slight convex curve.

Sutures not crenelate.

The height of the columnals in any one entrochus is about the same; but there is considerable variation in the relative heights of different specimens, as shown by the following measurements in millimetres:

Diameter . .	1·1	1·4	1·6	2·5	2·7	2·7	2·7	3·1	3·9
Height . .	1·0	1·23	1·7	1·4	0·9	1·1	1·3	1·3	1·0
Ratio . .	0 9	0·87	1·06	0·56	0·3	0·4	0·48	0·42	0·25

On the whole, these numbers follow the rule that the ratio of height to diameter is greater in younger stems. The last of these is the only one of the sixty that exceeds 3·1 mm. diameter; its joint-faces are not clearly shown, and it is just possible that it does not belong to this species.

Joint-faces: — lumen minute; area small, slightly roughened, apparently not raised. The ridges radiate to the periphery, and may either dichotomise as they go or be increased in number by the intercalation of similar ridges. Well-preserved faces show fine concentric grooves, which cut across the radiating ridges and give them the beaded or cancellate appearance that has suggested the name. In the strength of the ridges and of the concentric grooves, as also in the extent of the central area, there is considerable variation. The number of ridges tends to increase with the diameter of the joint-face but the ratio is not constant. Thus —

in a columnal	1·2	mm. diameter,	about	18	ridges	reach	the	periphery	
»	1·2	»	»	24	»	»	»	»	
»	2·0	»	»	42	»	»	»	»	(some quite short)
»	2·1	»	»	46	»	»	»	»	
»	2·6	»	»	64	»	»	»	»	(particularly delicate)
»	3·1	»	»	54	»	»	»	»	(very delicate)

The invisibility of crenellae on the sutures is due to the tenuity of the ridges.

R e l a t i o n s o f t h e s p e c i e s. — These joint-faces closely resemble those of the striate type in *Encrinus granulosus*. That, in fact, is why the columnals are referred to *Encrinus*. The difference lies chiefly in the small size and greater fineness of the markings, which appear to be relatively, as well as absolutely, more delicate. In *E. granulosus* the sutures are crenelate; or, if the crenellae cannot be seen, that is due to the presence of a peripheral rim, which structure does not occur in any of the present specimens. From all other species of *Encrinus* or *Entrochus* that I can find described, and certainly from all named Triassic species, *E. cancellistriatus* differs in the same points as do the striate trochitae of *E. granulosus.* The relatively large number of specimens, their occurence at two localities, the absence of the striate form of the true *E. granulosus*, and the structural features just mentioned prevent me from regarding the columnals as derived merely from dwarfed individuals of *E. granulosus.* It is however possible that they represent a small race of a species as yet undescribed and living at a later date. Thus, a fragment of Hallstätter Kalk from Steinbergkogel, preserved in the Hofmuseum at Vienna, is full of columnals closely resembling those of the present species, though the largest attains a diameter of 4·7 mm. with a height of 1·8 mm. A similar but much larger form from the Hallstätter Kalk of Leisling near Goisern, and from the Karnische Stufe, zone of *Tropites subbullatus*, from Rapoltstein near Hallem, Salzburg, is also in that Museum.

Encrinus sp.

(Plate I, fig. 23.)

A single columnal from the Cassian of Cserhát is placed with this genus because of its general resemblance to certain *Entrochi* assigned to *E. cassianus* by LAUBE (1865), especially that represented in MÜNSTER (1841) pl. V, fig. 4 *c*, and to a less extent that in LAUBE (1865) pl. VIII *a*, fig. 5*g*.

Side-faces convex, with, in addition, a well-marked ridge, at about half the height, slightly wavy in outline and a little irregular. Ridges on joint-face not clear, about 15, apparently short.

Diameter at ridge 1·65 mm. Diameter at joint-face 1·3 mm. Height 1·2 mm.

Encrinus sp.

Two columnals from Muschelkalk of Felsőörs, and Tamáshegy near Balatonfüred are too ill preserved to be further determined. Their measurements in millimetres are:

Diameter	6·8	8·8
Height	10·8	4·5
Diameter of lumen . . .	0·5	

Entrochus silesiacus.

(Plate I, figs. 24—25.)

1835. «Entrochiten ... vielleicht zum *Encrinites Schlottheimii* gehörig». F A. QUENSTEDT: Archiv f. Naturges., Jahrg. I, Bd. II, p. 228, pl. IV, fig. 3.

1858. *Entrochus silesiacus* H. E. BEYRICH: Abh. Akad. Wiss. Berlin, 1857, Phys. Kl. No. 1, p. 46.

1870. *Encrinus silesiacus* (BEYR.). — C. F. ROEMER: Geologie von Oberschlesien, pl. XI, fig. 9—10.

History of the species. — Other references might be given, but I am not convinced that all the forms assigned to this species by other authors really belong to it.

The specimen figured by QUENSTEDT (1835) appears to have been in the collection of H. von DECHEN, and its locality and horizon are given merely as

«Schlesischen Muschelkalke». The only locality given by BEYRICH is «Kamin bei Beuthen» (Ober-Schlesien). This also is the locality of the specimen figured by ROEMER. Prof. Dr. OTTO JAEKEL, who kindly examined the specimens in the Berlin Museum für Naturkunde at my request, tells me that the other localities there represented are Rossberg near Beuthen, and Mikultschütz, and that there is no difference whatever between the forms from these three localities. Reference to ROEMER (op. cit.) or to H. ECK («Über die Formationen des bunten Sandsteins und des Muschelkalks in Oberschlesien» Berlin, 1865) shows that the horizon of these localities is the same, namely the beds with *Spirifer Mentzeli* in the middle of the Lower Muschelkalk. The species then should be interpreted primarily by means of specimens from these localities, and this is attempted in the following account, based partly on Dr. JAEKEL's answers to my questions, partly on five entrochi from Rossberg which he kindly sent me (now registered Brit. Mus. E 7100, and here referred to as *a*, *b*, *c*, *d*, *e*), and partly on a large number of specimens from St. Hyacinth-Quelle near Beuthen, preserved in the Geological Museum of Tübingen University (16 of these, presented to the British Museum, are registered E 7116).

Section circular. Side-faces flat or slightly convex, very rarely concave. Sutures with fine, distinct crenellae. Joint-face in most quite level, with a small but distinct axial canal, varying from circular to pentagonal, from which ridges radiate to the periphery. These ridges are, as BEYRICH said, not granular but smooth and clean-cut. As they approach the periphery they increase in width and in number, the latter either by dichotomy or by the converse process — the intercalation of fresh ridges; thus in a joint-face 7·7 mm. in diameter, there are 15 ridges starting from the axial canal, and these have increased to 41 at the periphery. Incipient dichotomy of the ridges is frequently visible in the form of a groove running down the middle of each ridge for the whole or a part of its length. In some specimens a few of the longer ridges unite at their proximal ends to form a raised margin to the axial canal. In others there is, around the axial canal, a roughly pentagonal depression sometimes defined by a raised petaloid ridge, and within it may be either granules or finer ridges, due to a division of the main ridges by the above-mentioned median grooves. Neither cirri nor cirrus-facets are to be seen in the figures cited above or in the specimens at our disposal.

Measurements in millimetres are as follows:

	QUENSTEDT'S figure	ROEMER'S figure	E 7116	E 7100 *a*	*b*	*c*	*d*	*e*
Diameter	7·6	7·5	8·8	7·7	6·5	5·6	5·0	4·3
Average height of columnal	1·7	2·0	1·8	1·3	1·4	2·2	1·3	1·7
Diameter of lumen . . .	?	0·6	1·5	0·6	0·7	0·7	0·7	0·6

In 1859 K. von SCHAUROTH, doubtless in ignorance of BEYRICH's name, described and figured columnals from the Trigonella Limestone near Recoaro, under the new name *Encrinus ? radiatus*.[1] Except for the statement that his specimens, with a diameter of 4 to 6 mm., had a height of scarcely 1 mm., the differences between them and the true *E. silesiacus* are but obscurely indicated. It is therefore not surprising that H. ECK (op. cit. 1865, p. 88) referred these specimens to the latter

[1] Sitzber. Akad. Wiss. Wien, Math.-Nat. Cl. XXXIV, p. 288, pl. I, fig. 4.

species. But the specimen from Repten that ECK himself described as *Entrochus silesiacus* seems to have differed in important respects from those described above. In a length of 22 mm. were included 23 columnals, which rapidly decreased in diameter from 7 mm. to 4 mm.; the joint-face at the wider end agreed with the type, but that at the narrower end showed a clear pentapetalous pattern. Moreover 7 of the columnals were nodals, each bearing 5 or fewer cirri, alternating in orientation with the petaloid areas. The joint-faces of the cirri were radiately striate.

Somewhat similar forms to these last were described by E. W. BENECKE in 1868[1] as occurring at Recoaro, and were by him identified with both *Encrinus? radiatus* and *Entrochus silesiacus*, the latter name having the preference. While the cirrus-facets appear to agree with ECK's description, the pattern on the joint-face has not a true pentapetalon in the centre, but rather 5 radial ridge-groups, the elements of which are placed gable-wise, and abut on, without merging into, the peripheral ridges.

In «Petrefactenkunde Deutschlands» (IV, p. 479; 1875) QUENSTEDT carefully distinguished these and other forms from the true *E. silesiacus*; but in a later paper containing a valuable summary of the Muschelkalk *Encrini*,[2] ECK still includes all these forms under *Entrochus silesiacus.*

I have been kindly permitted to study at Tübingen the material on which, presumably, QUENSTEDT based his decision, and to bring home a few columnals for more detailed examination. I thoroughly agree with QUENSTEDT (1875). In the Beuthen material I find the true *Entrochus silesiacus* as above described (Brit. Mus. E 7116), columnals indistinguishable from those of *Encrinus liliiformis* (E 7117), columnals of an *Isocrinus* (E 7114), of which some are nodals with well-developed cirrus-facets (E 7113), and columnals more like those of *Balanocrinus*, with long peripheral crenellae or striae and with small, less regularly developed cirrus-facets on the nodals (E 7115). In material from the Muschelkalk of Montecchio Maggiore, Recoaro, I find columnals of the same species of *Isocrinus* and the same apparent *Balanocrinus*. The latter is undoubtedly the *Encrinus ? radiatus* of SCHAUROTH, and must stand as a valid species, *Balanocrinus radiatus*, perfectly distinct from *Entrochus silesiacus*, which is probably an *Encrinus*, and hitherto has not been recorded from Recoaro.

So far as the distinctness of these two species is concerned, this view appears to be that adopted by KOKEN in his careful description of *Entrochus rotiformis* from China;[3] but I do not agree with his remark that «Das Auftreten von Ansatzflächen für Cirrhen . . . ist kein ausschlaggebendes Merkmal, sie von *Encrinus* zu trennen».

Material from Bakony. — This matter has been discussed at some length because it is to the original type of *Entrochus silesiacus*, and not to the cirriferous species, that I would refer a stem-fragment from Alsódörgicse, Hangyáserdő, embedded in a white, highly crystalline limestone (figs. 24, 25). The study of the fragment is rendered difficult by the intense secondary calcification, which has obscured the structure and made the whole so brittle that the joint-faces cannot be properly exposed.

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[1] «Ueber einige Muschelkalk-Ablagerungen». Geogn.-Palaeont. Beitr. II, (1), p. 41, pl. IV. fig. 12.
[2] Zeitschr. deutsch. geol. Ges., XXXIX, p. 558; 1887.
[3] Neues Jahrb. für Min. 1900, I, p. 212, pl. X. figs. 16—25.

Total length of fragment about 34 mm. Width 8·6 mm. Average height of a columnal 1·5 mm., with no obvious alteration of height. Section circular. Side-face flat or slightly convex. Crenellae visible from outside, though not very clearly. Lumen apparently rather small, but its outlines are not distinguishable. Radial striae clean-cut but not deep, and apparently reach lumen. The ridges gradually increase in width, and some of them fork at about half-way to the periphery. The total number of crenellae cannot be counted, but I should estimate it at not less than 50. The relative size of the crenellae agrees with that in typical examples of *E. silesiacus*, and their number is consistent with the slightly greater diameter. There is no trace of cirri.

This determination is of importance, because there is believed to be no other evidence for the age of the rock in this locality. This evidence indicates a Lower Muschelkalk age.

Entrochus sp.

(Plate I, fig. 26.)

There is a fragment from the Cassian beds of Cserhát, consisting of two columnals which can not well be referred to any described species.

The height of a columnal is 1·25 mm., the diameter is 1·5 mm. The sides are slightly convex. One joint-face shows very fine radiating striae, which are not quite regular, but seem to anastomose.[1] The suture between the ossicles is obscure. The other joint-face scarcely shows the striae, only a faint roughness, perhaps due to weathering.

With this may provisionally be placed two columnals, also from Cserhát, that have joint-faces similar to the last mentioned, and convex sides. Their measurements in mm. are:

Diameter . . .	1·3	1·5
Height	1·1	0·75

Trochita sp.

(Plate I, fig. 27.)

A single columnal from the Cassian beds of Cserhát. Sides smooth, slightly convex. Joint-faces show a minute axial canal, a smooth depressed central area, surrounded by slight, irregular elevations, which might be crenellae either worn or modified; they are short and do not quite reach the periphery.

Measurements: Height 1·3 mm.; greatest diameter 1·5 mm.

This reminds one of *Eugeniacrinus* or possibly *Millericrinus* rather than of *Encrinus*.

Entrochus sp. indet.

Three fragments of columns from the Cassian beds of Cserhát, and one columnal from bed e 4, at cutting VI on the Veszprém-Jutas railroad, are not well enough preserved for description. They are all of small diameter.

[1] The arrangement of the striae reminds me of the specimen that S. v. Wöhrmann referred incorrectly to *Encrinus granulosus* (Jahrb. d. k. k. Geol. Reichsanst., Wien, XXXIX. p. 191, pl. V. f. 8; 1889). That, however, has a diameter of 5·8 mm.; it came from the Cardita Oolith of Suntiger, Haller Anger (See p. 11.).

Trochita sp.

In the museum of the Hungarian Geological Institute is a columnal from Felső Eörs, registered 10. 52. 1870, and said to come from Recoaro Kalk (Muschelkalk). It is labelled *Encrinus* [i. e. *Dadocrinus*] *gracilis*, but the joint-face does not present the usual characters of *Dadocrinus* (vide infra).

The columnal is barrel-shaped. The joint-face shows a small pentagonal lumen surrounded by a raised, rugose, flattened area, of which the rugosities merge into rather obscure radiating ridges, forming a circle within that of the peripheral crenellae, with which they are not continuous, although they appear to equal them in number, namely about 25. The peripheral crenellae are not deeply notched at the margin as in *Dadocrinus*. The mean diameter of the joint-face is 6·3 mm.

PENTACRINIDAE.

For definition, see Bather «The Echinoderma» p. 182; vol. III in «Treatise on Zoology», ed. E. R. Lankester. The primitive columnals, resembling those of *Dadocrinus* and *Holocrinus*, are dealt with first.

Dadocrinus.

1847. *Dadocrinus* H. v. Meyer: N. Jahrb. f. Mineral. 1847, p. 575.
1851. » H. v. Meyer: Palaeontographica, I, p. 266.
1887. » A. v. Koenen: Abh. K. Ges. Wiss. Göttingen, XXXIV, Phys. Kl. I, p. 5.

References to most of the previous literature are given by von Koenen. The genus was for long confused with *Encrinus*, and has only gradually won acceptance. Hence its columnals have, it is probable, often been figured as those of *Encrinus*, and this increases the difficulty of distinguishing between the two. The best figures are those given by Kunisch (Zeitschr. deutsch. geol. Ges. XXXV, pl. VIII, f. 6 *a—e*; 1883), but these are only of natural size. A few joint-faces, probably belonging to the genus, are represented, some enlarged, by v. Meyer (1851, pl. XXXI, ff. 11, 12, 15, 16, and perhaps others). Between columnals from the distal end of the stem of *Dadocrinus* and many columnals of *Encrinus* the figures show no difference except that of size. The extreme forms, however, as in Kunisch, f. 6 *a* and *e*, have not, so far as I am aware, been paralleled in *Encrinus*.

The normal type of joint-face, as exemplified in a slab labelled *D. Kunischi* from Sacrau near Gogolin, Silesia, (Brit. Mus., E 6078), presents a lumen relatively larger than in *Encrinus* (being 0·3 mm. in a columnal of 1·6 mm. diam.), surrounded by a smooth raised area, which may be circular or irregularly pentagonal with interradial angles. Ridges radiate to the periphery from the outside of the central area, with which their tops are on a level and often continuous, so that the grooves, which are clearly marked and increase in depth towards the periphery, appear as though notched in the rim of the columnal. Sometimes, however, the central area is separated from the ridges by a groove, which may be narrow or wide, and is concentric with the periphery. The number of ridges in the cylindrical portion of the stem usually comes within the limits 8—20 mentioned by Kunisch, whose fig. 6 *c*, however, shows 23 crenellae, and I have counted 25 in a circular columnal of 2·15 mm. diam. In surfaces with the larger numbers, a few of the ridges do not quite reach the central area, but are intercalated between the others. The ratio of the central area to the diameter of the columnal varies from 1 : 3 to 1 : 1·7. The ridges are longer towards the distal end of the stem. In the pentagonal proximal portion the ridges are numerous (25 or perhaps more) and short; and, since they remain at right angles to the sides, the first effect is to throw them into radial groups; but, with increasing radial indentation of the sides, the groups become inter-radial, as in *Isocrinus*. The essential elements are, however, the same throughout the stem.

Dadocrinus? sp.

(Plate I, fig. 28.)

A single entrochus from Cserhát, consisting of 2 columnals (one destroyed during examination), may belong to this genus. The specimen is much worn, with only one joint-face at all fairly preserved, and is coated with an iron-stained patina which obscures the suture between the two columnals. Its stereom, moreover, is more darkly stained than is usual in the Cserhát specimens. It is, therefore, probable that the fossil is derived from an older bed, possibly from one contemporaneous with the Muschelkalk, from which alone *Dadocrinus* has hitherto been recorded.

Sides of columnals very slightly convex.

Diameter 1 mm.

Height of columnal 0·7 mm.

Number of crenellae 8, with apparently a new one arising to make 9.

The ridges are relatively coarse and have the peculiar notched appearance so distinct in *Dadocrinus*. They meet close to the lumen in a central area level with their tops.

As already said, some of the small specimens (*h—l*), referred doubtfully to *Encrinus cassianus,* may belong to *Dadocrinus*. Specimen *l* appears to resemble the present specimen, but its preservation is unsatisfactory. The joint-face of *h* is the most like that of *Dadocrinus*, but in the height of its columnals this specimen is the least like.

Entrochus quinqueradiatus n. sp.

(Plate I, figs. 29—34.)

Diagnosis. — Trochitae cylindrical or barrel-shaped, smooth, and of small diameter (1·2—3·65 mm.). Joint-faces with 5 strong ridges, or the corresponding grooves, radiating from the level central area to near the periphery, and in some cases accompanied by bounding grooves, or the corresponding ridges. Lumen minute.

Material. — Eight specimens from the Cassian beds of Cserhát lettered *a—h*, seem to be distinguished by the above characters, and to require a name. They consist of 1 (*a, d, e, g, h*), 2 (*b, f*), or 3 (*c*) trochitae each. Specimen *d* is selected as holotype.

Description of the specimens. — The appearances of the joint-faces may be explained thus: — In the simplest form are 5 ridges (shown in *a, g, h*), which fit into 5 grooves (shown in *a, e, g*) on the apposed surface. The sides of these grooves are, it is supposed, then raised, and thus is produced a joint-face with ten minor ridges (shown in *c, d, f*), apposed to a surface with 5 major ridges bordered by grooves (shown in *d*). The elevation of the surface between the last-mentioned grooves might result in the development of 5 intercalated ridges; but it is not easy to say certainly whether there are signs of this. The ridges are raised above the central area and sink to the general level of the surface just before reaching the periphery, which occasionally shows traces of a slightly raised bounding rim (shown in *g* and *h*). Thus there is no sign of crenelation at the sutures.

The following table gives the details. In it *R* and *G* stand for major ridges or grooves respectively, while *r* stands for minor ridges: where possible, a statement is made concerning each joint-face, and it will be seen that major ridges on the one surface often correspond to either simple major grooves or to minor ridges bounding major grooves on the other surface of the same columnal.

	a	*b*	*c*	*d*	*e*	*f*	*g*	*h*
Diameter . . .	1·2	1·2	1·3	1·4	1·6	1·75	2·3	3·65
Height . . .	1·0	1·2	0·6	1·5	1·5	2·0	2·0	1·8
No. of Ridges or Grooves	5R 5G	? 5R	5R 10r	?5R 10r	? 5G	? 10r	5R 5G	5R ?
Approximate length of ridge	0·25	?	0·4 0·5	0·4	?	0·5	0·6	1·1
Curvature of sides . .	convex by about 1/6 diam.	almost straight.	markedly convex by 1/4 diam.	convex by about 1/7 diam.	strongly convex 1/3 diam.	almost straight	almost straight	strongly convex 1/6 diam. or more

Relations of the species. — The general appearance reminds one of the columnar represented in Quenstedt's «Petrefactenkunde Deutschlands», pl. CVII, fig. 42, from the Wellenkalk of Deubach, and assigned by him to *Encrinus liliiformis*. Possibly that specimen, though a trifle large, belongs to the Wellenkalk form, *Holocrinus Wagneri*. Both it and our specimens resemble some of the figures of joint-faces given by R. Wagner in his account of that species, under the name *Encrinus gracilis* (Jena. Zeitschr. XX, pl. I, figs. 5*a*, 6*b*, and pl. II, fig. 6*c*). Those specimens are, however, clearly pentagonal, and the grooves are regarded as smooth petaloid areas directed towards the angles of the column (i. e. interradial in position), and surrounded by crenellae, which may, it is true, be very faint. Our specimens, on the other hand, are quite or almost circular, and show no trace of crenellae. It is just possible that the depressions in the largest of our specimens (*h*) are smooth petaloid areas; but the isolation and prominence of the ridges militate against this view.

Holocrinus.

1886. (?) *Holocrinus* C. WACHSMUTH & F. SPRINGER: Revision of Palaeocrinoidea, III, p. 215; Proc. Acad. Nat. Sci. Philadelphia, 1886, p. 139.
1893. *Holocrinus* O. JAEKEL: Sitz.-Ber. Ges. naturf. Freunde Berlin, 1893, p. 201.
1899. » F. A. BATHER: Rep. Brit. Assoc., 1898, p. 922.
1900. » F. A. BATHER in E. R. LANKESTER'S „Zoology, III, Echinoderma". p. 182.

A history of opinion concerning this genus, with an account of its structure, was given by JAEKEL, who, however, did not define its systematic position. I have placed it with *Dadocrinus* at the base of the Pentacrinidae. Up to the present only two species have been described, namely, the genotype, *Encrinus Beyrichi* K. PICARD (Zeitschr. deutsch. geol. Ges. XXXV, p. 199, pl. IX; 1883.), from the Lower Muschelkalk near Sondershausen, and *Encrinus Wagneri* E. W. BENECKE (Neues Jahrb. f. Min. 1887, Bd. I, p. 378), based on a specimen described as *Encrinus gracilis* by R. WAGNER (Jena. Zeitschr., XX. p. 6, pls. I, II; 1886) from the lower Wellenkalk near Jena.

The Stem is the part that chiefly concerns us. That of *Holocrinus Beyrichi* is said by PICARD to be pentagonal throughout, about 1 mm. in diameter, with columnals varying in height from 1 mm. at the proximal end to 2·5 mm. at the distal end. The joint-faces have not been observed, but the sutures are crenelate. Cirri are borne in verticils of 5 by slightly swollen nodals, at intervals of 8—10. The cirrals are cylindrical. In *H. Wagneri*, as fully described and illustrated by WAGNER, the stem is pentapetalous in its proximal region, and passes gradually through pentagonal to cylindrical in the distal region. The diameter is from 1 to 2·7 mm. The columnals alternate in height in the proximal region, the average being about 0·3 mm.; from this they increase to 1 or even 1·2 mm. in the distal region, the higher ones however being often compound ossicles. The joint-faces of the proximal region may be smooth [these probably being syzygial] or crenelate, the crenellae being around 5 narrow petaloid areas; those of the median region are peripheral in 5 groups, and are visible on the suture. In the distal region, the crenellae appear to be simply peripheral, but often obscured. The cirri are borne in whorls of 3 or 2 on nodals at intervals of 13 to 16. The more proximal cirrals are oval in section, the more distal ones cylindrical. The cirrus-facets of the nodals are transversely or longitudinally elliptical, with a transverse fulcral ridge broken centrally by the axial canal.

Holocrinus sp.

(Plate I, fig. 36.)

Material. — A fragment of pinkish-grey crystalline limestone (6 × 3·3 cm.) from Balaton-Füred, Zala megye, Tamáshegy, said to be of Muschelkalk age, bears on its weathered surface numerous scattered columnals, some brachials, and a few connected ossicles that I take to be fragments of cirri.

Description of the Specimen. — One relatively large columnal (3·6 mm. wide, 2·5 mm. high) appears to belong to *Encrinus*, but is not well preserved.

The other columnals, which do not exceed 2·2 mm. in diameter, agree, so far as their state of preservation permits of comparison, with the description of *Holo-*

crinus Wagneri. They vary in section from circular to quinquelobate, and some joint-faces show traces of the appropriate pattern as described above. Others come nearer to the *Entrochus quinqueradiatus* just described. The supposed fragments of cirri are thin, straight, and apparently cylindrical. No cirrus-facets can be detected on any of the columnals, but the surfaces are so weathered that such facets may have occurred but have been obliterated. The brachials are simple, approximately semi-circular in section with a wide V-shaped ventral groove; they are rather longer than wide.

Relations of the Specimen. — It is an assumption that all these parts belonged to the same species; but it would perhaps be a greater assumption to suppose that they belonged to more than one species. A cirriferous stem containing ossicles of this nature is characteristic of *Holocrinus Wagneri*, and neither cirrals nor brachials present any features inconsistent with their reference to that species. At the same time the evidence that they did belong to it is far from conclusive.

Entrochus cf. «*Pentacrinus venustus*».

(Plate I, fig. 35.)

1843. *Pentacrinus venustus?* Klipstein: Geol. Östlich. Alpen. p. 277, pl. XVIII, f. 24 *a—c*.

Material. — Two stem-fragments (*j*, *k*) and eight ossicles, possibly cirrals (*a—h*), from the Cassian beds of Cserhát (Leitnerhof), appear to belong to one of those puzzling transition forms between the *Encrinus* stage of development and the Pentacrinine stage.

Description of the Specimens. — Specimen *j* is a single columnal, with diameter 1·8 mm., height 0·9 mm., sides very slightly convex, section slightly subpentagonal. The joint-face shows a minute lumen, surrounded by a slightly granular central area, the granules merging into fine ridges. The ridges are divided into 5 groups, of about 6 in each, the median ridge or ridges in each group being the longest and coinciding with a radius of the circle, the others being parallel to it, and the outer ridges of each group meeting those of the adjacent group. Each group corresponds to a side of the subpentagon.

Specimen *k* consists of two columnals united by an obscure suture, probably representing a syzygy. Height of the pair 1·5 mm., giving as average height of a columnal 0·75 mm., diameter at the syzygy 1·6 mm. The joint-faces are as described in the other specimen. The side-faces of the pair are slightly convex, the greatest width being at the syzygy. At the level of the syzygy are 5 markings, each corresponding with the middle longer ridge of each group. One of these markings, which is the largest and the most raised on a swelling above the general level, shows a shallow circular depression, with a minute central lumen and a raised, faintly crenelate margin. Another, adjacent to it, is smaller, a little less raised, and not so clear in its details. A third, adjacent to the last, is still slightly raised, but is smaller and quite obscure. The two others are little more than obscure scars which, were it not for their definite radial position, might pass unobserved. Clearly all these markings are in the nature of facets for cirri, perhaps all functional at one time in the growth of the stem; but only the two larger can be said, without doubt, to have borne cirri at this stage. The cirrals, it may be inferred, were circular in section and with crenelate or radiately ridged joint-faces. The diameter of the largest cirrus-facet is 0·3 mm.

It is possible that to larger columns of the same species we should assign, as cirri, some slender fragments also from Cserhát. These fragments, lettered *a* to *f*, are composed of elongate ossicles with small crenellae at the sutures. Some are slightly flattened. The average measurements in millimetres of the component ossicles are:

	a	*b*	*c*	*d*	*e*	*f*
Diameter	1·2	1·1	1·1	1·05	0·9	0·9
Height	1·15	1·5	1·2	1·46	1·4 & 1·0	0·9

In *a*, *b*, *d*, and *e*, the sides of the ossicles are slightly concave; in *c* they are straight; in *f*, convex. In *a* and *c*, the sutures are very indistinct. In *d* there is a swelling half-way down each ossicle, suggesting that it consists of a fused pair; one of these swellings looks as though it were due to cirrus-facets, in which case the specimen would be a fragment of a small stem, not of a cirrus.

There are two other fragments: one (*g*) a single ossicle, with diameter 1·9 mm. and height 3·3 mm. and convex sides; the other (*h*) composed of three ossicles, with diameter 1·65 mm. and height 2·5 mm. and very slightly concave sides These may possibly be fragments of cirri of an allied but larger species than that to which *a—f* belong.

Relations of the Species. — The various fragments under discussion are too incomplete and too obscure to bear the weight of an independent specific, still less of a generic, name. This is not the place in which to discuss the systematic position of «*Pentacrinus venustus*», to which they appear allied. But I must express my conviction that, had Professor LAUBE troubled to examine KLIPSTEIN's types (Brit. Mus. 75860 *a* and *b*) he could never have referred them to *Pentacrinus* [i. e. *Balanocrinus*] *laevigatus* MÜNSTER. As I hope to prove elsewhere, there is scarcely any point of resemblance, beyond the cylindrical shape and smooth exterior of the columnals. In fact neither «*Pentacrinus venustus*» nor the fragments herein described can be placed in the *Pentacrininae* as nowadays understood. They might belong to some otherwise undescribed species of *Holocrinus*.

SUBFAMILY: PENTACRININAE.

Pentacrininae BATHER, 1900, in «A Treatise on Zoology», ed. E. R. Lankester, vol. III, «The Echinoderma», p. 182.

The genera included in this Subfamily are *Pentacrinus* BLUMENBACH (syn. *Extracrinus* AUSTIN), *Isocrinus* MEYER (syn. *Pentacrinus* P. H. CARPENTER), *Balanocrinus* AGASSIZ em. LORIOL, *Austinocrinus* LORIOL, and *Metacrinus* P. H. CARPENTER. The Pentacrinine columnals found in Triassic rocks have hitherto been referred to *Pentacrinus*. That genus, however, as properly restricted, finds its earliest representative in *P. versistellatus* SCHAFHÄUTL, from the zone of *Avicula contorta*; the type-specimens are in the Palaeontological Museum of Munich, where I have examined them. No species of that genus is known from the Balaton district. Some of the Triassic species, e. g. *Pentacrinus subcrenatus* and *P. laevigatus*, do not belong to *Penta-*

crinus in the sense either of BLUMENBACH or of CARPENTER. They are early representatives of *Balanocrinus,* as P. de LORIOL has already suggested in part. The rest of the so-called Triassic *Pentacrini* must now assume the name *Isocrinus,* as shown below.

The remains of *Pentacrininae* from the neighbourhood of Veszprém consist almost entirely of columnals, but since all species of *Pentacrininae* hitherto described from the Trias are based on columnals, this circumstance does not hinder the task of comparison. The characters presented by the columnals of this Subfamily are so numerous, so variable within the Subfamily, and yet so constant within the species, that they furnish a secure foundation for systematic work. The statement that they are constant within the species must, however, be qualified by the remark that they vary with the age of the columnal, and consequently also differ much in different regions of the stem.

Previous writers on Triassic *Pentacrininae* have scarcely realised how many characters it was not merely possible but necessary for them to mention if they would discriminate between the species. Several of the published diagnoses include only such characters as are common to a large number of species, if not to a whole genus. Some of them also are either unintelligible, or incorrect, or both, while the remarkable inaccuracy or insufficiency of the published figures has led to numerous inaccurate determinations.

The study of the Veszprém crinoids had, therefore, to be preceded by a fresh and detailed study of all the type-specimens of Triassic *Pentacrininae* Here the results of that study can only be alluded to incidentally. But if certain statements appear dogmatic and unexpected, my readers will kindly remember that they are the fruits of a first-hand examination.

Terminology of the Pentacrinine Stem.

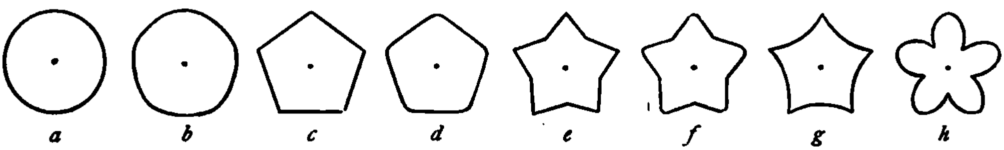
Finer discrimination necessitates longer descriptions. But in order to reduce their length so far as possible, it is advisable to give a general account of the Pentacrinine stem, introducing a concise terminology.

That end of the stem which is nearest the cup is termed p r o x i m a l, the end furthest away from it being d i s t a l. The same terms are applicable to each region of the stem, to the cirri, and to the upper and lower surfaces of a single columnal or cirral. The terms «upper» and «lower» postulate a normal sessile position, with the crown directed away from the sea-floor. But since it is highly probable that some *Pentacrininae* hung downwards from floating logs, those terms may be misleading. It is, however, advisable that, in figures of the stem or of portions of it, the proximal end should be uppermost. This has not always been attended to.

In transverse section (text-fig. 1), a columnal may be (*a*) c i r c u l a r; or (*b*) s u b- c i r c u l a r, i. e. depressed radially so as to approach a pentagon, but the sides and angles still all convex; or (*c*) p e n t a g o n a l, i. e. with five straight sides, meeting at five interradial angles; or (*d*) s u b p e n t a g o n a l, i. e. a pentagon with rounded angles; or (*e*) s t e l- l a t e, i. e. when the interradial angles are less than 72°, so that the sides containing them meet radially to form five re-entrant angles; or (*f*) s u b s t e l l a t e, i. e. when the interradial angles are rounded, but the re-entrant angles remain bounded by straight sides; or (*g*) concavi-stellate, i. e. when the re-entrant angles are merged in concave curves; or (*h*) quinquelobate, i. e. when the re-entrant angles are bounded by convex curves continuous with those rounding off the interradial angles. Briefly, then, the section may be (*a*) a circle, (*b*) a laterally flattened circle, (*c*) a pentagon, (*d*) a rounded pentagon, (*e*) a star, (*f*) a rounded star, (*g*) an excavate star, or (*h*) a pentapetalon.

The union or plane of union between two columnals is a joint, and the apposed surfaces of the columnals are joint-faces. The whole outer surface of a columnal is the side-face, and is thus distinguished from the side of the pentagon or star. In a series of joined columnals, the lines along which the joints cut the side-faces are called suture-lines; originally such a line was termed a suture, but this term has been extended to mean a kind of joint.

Columnals are divided into nodals, which bear cirri; and internodals, which lie between them. In every stem, at any rate in its more proximal region, it is possible to distinguish columnals of different sizes, representing as many stages of growth: the nodals, which are the first to be formed, are always the largest, and may therefore be described as columnals of the First Order or, more briefly, I columnals; those next formed, and therefore the next in size, are columnals of the Second Order or II columnals; continuing, we distinguish a Third Order or III columnals, a Fourth or IV columnals, and so on. The distinction in size between columnals of the several orders



Text-figure 1. Transverse sections of the Pentacrinine Stem.

is always more obvious in the proximal region, while in the distal region it may vanish altogether, at least so far as the internodals are concerned. In the *Pentacrininae* the height of a columnal (i. e. the vertical measurement of its side-face) is always less than its diameter, and increases with age more slowly than does the diameter. Thus the relative height of the columnals decreases with age.

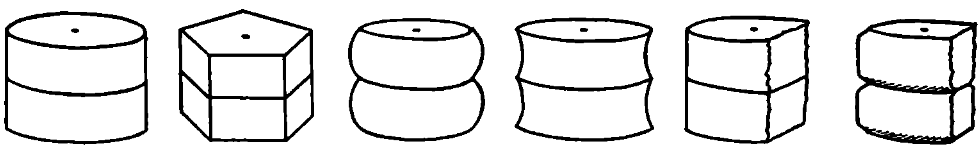
The columnal immediately proximal to each nodal has been distinguished by P. H. Carpenter as a supranodal, and that distal to each nodal as an infranodal. Each nodal is united to its infranodal by a rigid but brittle joint called a syzygium or syzygy. With reference to this joint, the nodal is termed epizygal, and the infranodal hypozygal. These terms are particularly useful in distinguishing the surfaces that meet at the syzygy.

Nodals or epizygals are always marked by cirrus-facets and are nearly always swollen (i. e. obviously of greater diameter than the adjacent columnals) especially at the interradial angles, but are often more excavate in the re-entrant angles. Portions of the nodal cirrus-facets may extend on to either the infranodal or the supranodal; and those columnals may then share in the modification of the nodals. Apart from this, a median vertical section of a columnal may have the sides straight (*a*, *b*), or convex (*c*), or, rarely, concave (*d*). For the sake of brevity, these terms may be applied directly to the side-faces (text-fig. 2). If the side-faces be straight and the transverse section circular, then the internode is cylindrical (*a*). If the side-faces be straight and the section pentagonal, then the internode is basaltiform (*b*). If the side-faces be markedly convex, and the section circular, then the internode approaches moniliform (*c*); a truly moniliform stem can hardly be said to occur among *Pentacrininae.*

The suture-line is usually flush with the side-face (text-fig. 2 *e*), but may be depressed in a groove (text-fig. 2 *f*), the upper and lower halves of which respectively form a rebate around each joint-face. The depression of the suture is frequently confined to the radial regions; if this be carried far, as is often the case in stellate, substellate, or concavistellate columnals, there is developed a transverse ridge at half the height of the columnal, and so is produced the scalariform type of internode. A stem may be scalariform and stellate in its proximal region, and gradually change to cylindrical in its distal region.

In addition to the changes in external form produced by variation in size or shape of the columnals, there may be ornament on the side-faces. This consists usually of small tubercles, which may grow together into horizontal or vertical ridges. If such ornament be absent, the side-faces are described as smooth.

The joint-faces between ordinary internodals are described as normal and, though they may be slightly different in the different regions of the stem, or where they approach the nodals, present no marked variation within a single species. The joint-faces of the syzygy are called syzygial; they usually differ considerably from the normal, especially in pro-



Text-figure 2. Internodals of the *Pentacrinine* STEM.

portion to their distance from the proximal end of the stem, and that of the epizygal often differs from that of the hypozygal.

The joint-face is divisible into five similar interradial sectors*, each of which is bilaterally symmetrical. In the centre of each joint-face is the opening of the axial canal or lumen, which may be circular, or pentagonal, or quinquelobate. The angles or lobes, when present, do not alternate with the angles of the columnals, but are like them interradial. This variation from ordinary crinoid structure is probably due to secondary growth of stereom, and the statement seems liable to exceptions. At any rate the axial cords of the stem are radial, and the branches from the axial canal to the cirri are inevitably radial, so that the lumen of the stem on approaching the node tends to develop radial lobes. So little attention has been paid to this point, now known to be of deep significance, that the published figures can scarcely be trusted. Thus, even in P. H. CARPENTER'S Challenger Report (pl. XXXII), we find the lumen of the same syzygy with interradial angles in figure 1, and radial angles in figure 2.

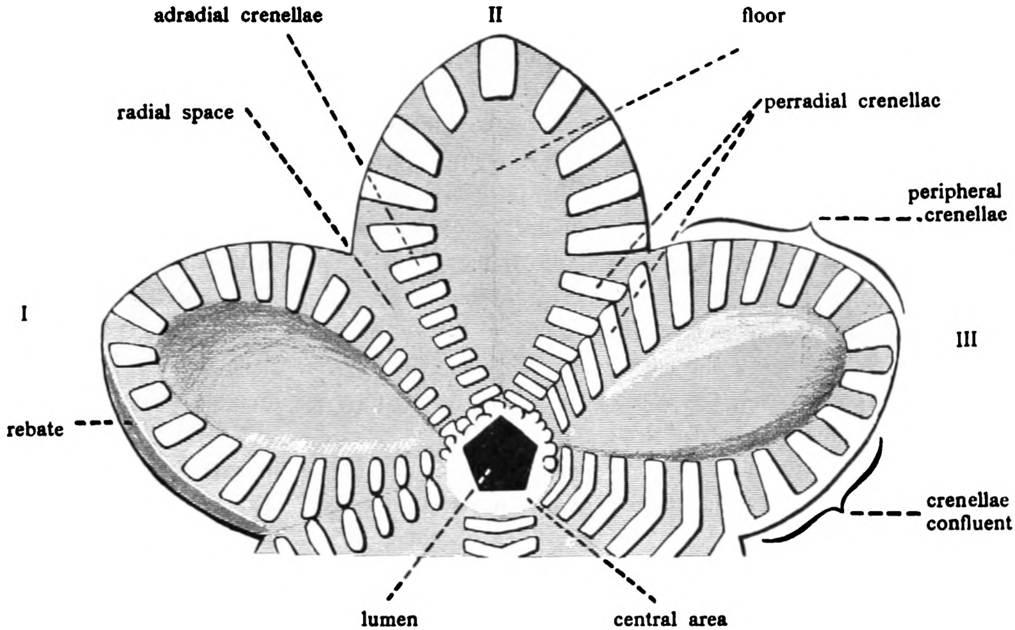
We proceed with the normal joint-face (text-fig. 3).

Surrounding the lumen may or may not be a distinct central area. This may be flush with the general floor of the joint-face, depressed below it, or raised above

* P. H. CARPENTER in some passages (Challenger Rep. Stalked Crinoids, p. 271) has used the term «sector» for the petaloid figure formed by the crenellae; but such restriction of a familiar term is scarcely warranted.

it. The flush area may be smooth or granular. In the latter case the granules may be distinct or concresced. It is the complete concrescence of the granules that produces the raised area. The concrescence of granules may be confined to a rim close round the lumen, and this rim may be circular or pentagonal, with angles either radial or interradial.

Between the central area and the periphery a varying smount of space is occupied by the rosette, composed of five petals, each petal symmetrical about an interradius, and consisting of a median floor surrounded by crenellae. The floors are usually flush with the general level of the joint-face and with the bottoms of the grooves between the crenellae, but may be depressed below that level, especially in their centres; in



Text-figure 3. Diagram of three sectors, numbered I, II, III, of the joint-face of a Pentacrinine internodal. Lumen pentagonal; central area raised, showing above its formation from concresced granules; floor depressed in sector I, flush in II, raised in III; radial ridge-group between sectors II & III consists of inosculating crenellae, that on the other side of III consists of gable-shaped crenellae; the radial ridge-group on the lower side of sector I is of *Balanocrinus* type.

rare cases they are slightly raised above that level. They mark the positions of the ligamentar strands on which the internodals are threaded; they might be called ligament areas were they not also traceable at the syzygies, where the strands do not pass. The crenellae round each floor tend to lie at right angles to its outline; the adcentral crenellae may merge into the granules of the area when such are present; those lying along the sides of any petal and not reaching the periphery may be called the adradial crenellae; those which reach the periphery are peripheral crenellae. The adradial crenellae of one petal may be separated from those of the adjacent petal by a radial space. In *Pentacrinus* (s str.) this is a large triangle, with its apex at the central area and its base on the peripheral rim. In *Isocrinus* a radial triangle may be present, but it never comes so close to the centre; or, on the contrary, the radial space may be restricted to a narrow radial groove, which combines with the corresponding groove of the adjacent joint-face to form a radial canal, running from the central area (not from the actual lumen) to the periphery, where it is visible on the suture-line as a radial pore («interarticular pore» P. H. CARPENTER); this structure is generally limited to the proximal region of the stem. In most columnals of *Isocrinus*, especially those from the distal region of the stem, the radial space is either limited to a small triangle or obliterated, and the adradial crenellae of one petal meet those of the adjacent petal, either inosculating and alternating with them, or joining symmetrically at their ends to form a series of gables, of which the apex is acentral. Such combinations of adradial crenellae may conveniently be spoken of as perradial crenellae, constituting radial ridge-groups. In *Balanocrinus* the perradial crenellae are not gable-shaped but lie almost straight across the perradius, while in extreme cases they become so short that the radial ridge-groups are little more than single lines of granules. There is no morphological distinction between a peripheral and an adradial crenella. With the growth of the columnal, peripheral crenellae gradually become adradial, and eventually perradial, while new crenellae make their appearance at the interradius. Therefore in any columnal these last are the shortest of the peripheral crenellae, and the outermost or adradial peripheral crenellae are the longest of all.

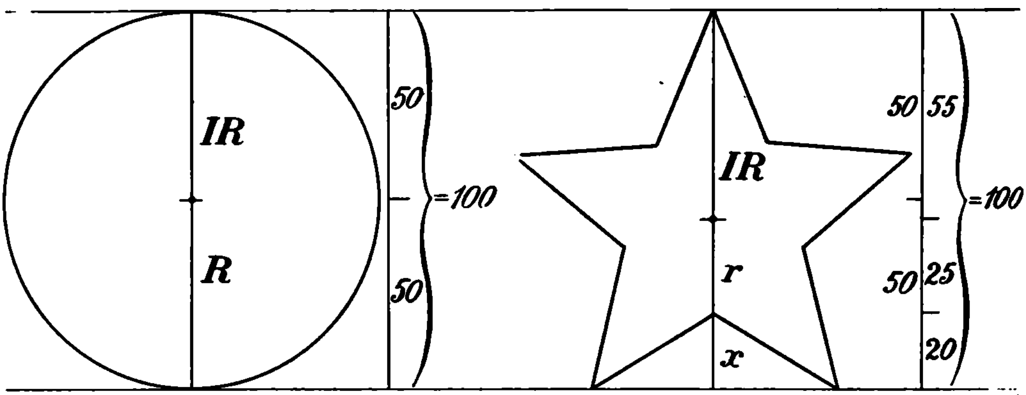
The outcrop of the crenellae on the periphery produces a crenelate suture-line. But peripheral crenellae may exist without the crenelation of the suture-line being obvious. This happens when there is a rebate rim to the joint-face, the two rebates producing by their apposition a depressed suture-line, as explained above. This rim appears to be a later formation, and therefore may not be found in all columnals of an individual. The external crenelation is still more obscured when the outer ends of the crenellae are confluent, so that the grooves between them are partly or wholly filled up; thus the suture-line becomes only faintly sinuous, or even straight.

The syzygial joint-faces are modified from the normal in two ways: first, by the obscuration or even obliteration of the normal rosette; secondly by the development of special structures in its place. The former modification, which increases with age, affects both epizygal and hypozygal faces in a similar manner, but is generally more pronounced on the epizygal. The latter affects the two faces differently. Thus, both faces are usually more indented radially than are normal joint-faces, but the indentation is greater on the epizygal. The petals of the epizygal are usually hollowed, in which case those of the hypozygal are swollen, so as to fit into the hollows. The radial spaces of the epizygal are sometimes raised, forming as it were an arch over the cirrus-facet and its lumen; in that case there is a corresponding depression in the hypozygal. Sometimes, while the crenellae homologous with those of the normal joints become almost or quite obliterated, a fresh set of very much finer and shallower crenellae appears in their place (see, for example, *Isocrinus Hercuniae*, pl. IV, fig. 109).

Each cirrus is articulated to the nodal by a cirrus-facet. Most species bear 5 of these on each nodal, and that number is to be understood unless the contrary is stated. Some species are alterni-cirrate (see P. H. CARPENTER «Challenger Report, Stalked Crinoids» sub *Pentacrinus alternicirrus*), that is to say, bear two cirri on one node, three cirri on the next, and so on, always alternating in radial position. The cirrus-facet may be indented, flush, or raised. In outline it is usually elliptical, and, except in *Pentacrinus* (s. str.), the long axis is transverse, i. e. parallel to the columnar joints; such a transverse ellipse may become ellipsoidal by the flattening of the upper or lower margin. In *Pentacrinus* the long axis is vertical and the ellipse may become rhomboidal, ovoid, or even pyriform. The facet has a lumen emerging on the diameter that corresponds with the columnar perradius; if it bisects that diameter it is central; but it may be supra-central or infra-central, according as it is nearer the proximal or distal edge of the columnal. The fulcrum is a ridge parallel to the transverse axis, and above, below, or coincident with it. The fulcrum may be above, below, or on the level of the lumen, and in the last case it may be either interrupted by the lumen or continuous around it. The margin of the facet may be raised in a rim, which, however, is not at the extreme edge, and therefore is visible even when the facet is indented. The semicircular areas between the rim and the fulcrum are muscle-fossae.

In transverse section the proximal cirrals usually have an outline identical with, or approximating to, that of the cirrus-facet. Their joint-faces may differ in detail from the cirrus-facet, but they have the same essential elements of the bifascial articulation.

Mode of measurement. For purposes of comparison it is not enough to give measurements; one must also state how these have been taken. Since no rules have hitherto been formulated for the measurement of crinoid-stems, it is necessary to explain the method here followed.



Text-figure 4. The diameters of a cylindrical and of a stellate columnal contrasted. The exact ratios for a pentagon are given in the text.

The diameter of a columnal passes through the lumen at right angles to two parallel planes, which touch the periphery, but nowhere cut it, and ends where it meets those planes (text-figure 4). When the section of the columnal is circular, subpentagonal, or pentagonal, the diameter lies wholly within the columnal. But when the section is stellate or quinquelobate, the diameter passes outside it along a radius, and the plane that cuts it at this end touches the periphery (if the section be a mathematically regular figure) in two points. If the distance from the centre of the lumen to the periphery along the interradius be IR, and if the distance from centre to periphery along the opposite radius be r, then in a cylindrical or basaltiform columnal, Diameter $= IR + r$; but in stellate or quinquelobate columnals, Diameter $= IR + r + x$ (i. e. depth of re-entrant radial angle). Only in a mathematically circular section does Diameter $= 2\ IR$. For purposes of comparison it is advisable to reduce all measurements to a common standard. The diameter of the columnal is adopted as this standard and assigned a value of 100.

Thus, the length $IR = 50$ in a cylindrical columnal; but in a pentagonal or stellate columnal $IR = 55.28$, while $r + x = 44.72$. If $IR = 50$ were taken as the constant, $r + x$ would be 40.45. But it is usually easier to measure the diameter in actual practice.

The height of a columnal or a cirral is theoretically the distance between two planes laid flat on the joint-faces; but since the crenellae inosculate, this would make the height of an internode less than the sum of the heights of its internodals. Moreover, since columnals are rarely isolated, they can rarely be measured in this way. For the comparison of one specimen with another, one has to take the average of several successive columnals, thus compensating for inequalities of growth. When columns are curved the measurement on the convex side is greater than that on the concave, and the mean of the two is taken.

The measurements given in this memoir have been made with sliding callipers, reading accurately by a vernier to tenths of a millimetre. The calculations from these measurements have rarely been carried beyond the second decimal place.

In the number of internodals, the hypozygal is included; in other words, internode + epizygal = intersyzygium.

Isocrinus.

1767. *Isis* (pars) LINNAEUS: Syst. Nat., Ed. XII, tom. 1, pars 2, p. 1288.
1801. *Encrinus* (pars) LAMARCK: Syst. Anim. sans vertèbres, p. 379. Also J. ELLIS (1762), J. F. BLUMENBACH (1779—1807), and older authors generally.
1821. *Pentacrinites* vel *Pentacrinus* (pars) J. S. MILLER: Natural History of the Crinoidea, p. 46. Also T. and T. AUSTIN (1847), P. H. CARPENTER (1884), and later authors generally. Non *Pentacrinites* J. F. BLUMENBACH (1804).
1837. *Isocrinus* H. von MEYER: Mus. Senckenberg. II, p. 251.
1852. *Cainocrinus* E. FORBES: Monogr. Echinodermata British Tertiaries; Palaeontogr. Soc., p. 33.
1864. *Cenocrinus* WYVILLE THOMSON: Intellectual Observer, VI, p. 3. (Not intended as identical with *Cainocrinus*.)
1864. *Neocrinus* WYVILLE THOMSON: tom. cit. p. 7.
1875. *Picteticrinus* P. de LORIOL: Mem. Soc. Phys. Hist. Nat. Genève, XXIV, p. 297.
1898. *Isocrinus* v. MAYER, F. A. BATHER: Nat. Sci., XII., p. 253.

The reasons for the above synonymy were so exhaustively discussed in the paper last cited («*Pentacrinus*: a name and its history»), that they need no repetition here. The conclusions therein reached have gained quite as much acceptance as could be expected, and will therefore be maintained in the present memoir. In accordance with them the following well-known Triassic crinoids must now bear the name *Isocrinus*: —

Pentacrinus amoenus LAUBE, 1865, Denkschr. Akad. Wiss. Wien, Math.-Nat. Cl. XXIV, Abth. 2, p. 277, pl. VIII *a*, fig. 19 *a*. [? figs. 19, *b*, *c*, and ?? fig. 19 *d*.] The figured specimens are in the Geologische Reichsanstalt, Vienna, where I have examined them. I hereby definitely select the specimen drawn in LAUBE's fig. 19 *a* as lectotype, since it is doubtful whether the others belong to the same species. This species is found in the Cassian beds, and is not represented in the Balaton district.

Pentacrinus bavaricus G. G. WINKLER, 1861, Zeitschr. d. deutsch. Geol. Ges. XIII, p. 486, pl. VIII, fig. 6 *a—e*. The figured specimens are in the Palaeontological Museum, Munich, where I have examined them. That institution has kindly presented a paratype to the British Museum (registered E 7105). The species occurs in the Kössen beds, and is not known from the Balaton district.

Pentacrinus Braunii MÜNSTER, 1841, Beitr. z Petrefactenk. IV, p. 50, pl. IV, fig. 8 *a—d*. LAUBE was most probably correct in regarding this as a synonym of

P. propinquus. The specimen represented in MÜNSTER's fig. 8*c*. is in the Palaeontological Museum, Munich, and is certainly an epizygal of that species The other figured specimen is not forthcoming.

Pentacrinus Fuchsii LAUBE, 1865, Denkschr. Akad. Wiss. Wien. Math-Nat. Cl., XXIV, Abth. 2, p. 276, pl. VIII *a*, fig. 18. The type-material consists of five stem-fragments in the Geologische Reichsanstalt, Vienna, where I have examined them. They are from the proximal part of the stem of *Isocrinus propinquus*.

Pentacrinus propinquus MÜNSTER, 1841, Beitr. z. Petrefactenk., IV, p. 49, pl. IV, fig. 9 *a—c*. The type-material is in the Palaeontological Museum, Munich, but one cannot decide which are the actual figured specimens. With its synonyms *P. Brauni* and *P. Fuchsi*, this species is found in the Cassian beds. I have examined specimens from other horizons referred to it by WÖHRMANN, BROILI and others, but believe none of them to belong to *Isocrinus propinquus* (vide infra, p. 54). The species has not been found in the Balaton district.

Pentacrinus tyrolensis LAUBE, 1865, Denkschr. Akad. Wiss. Wien. Math.-Nat. Cl., XXIV, Abth. 2, p. 277, pl. VIII *a*, fig. 20. The figured specimen and five other stem-fragments constituting the type-material are preserved in the Geologische Reichsanstalt, Vienna, where I have examined them. The only diagnostic character mentioned by LAUBE, is the strongly crenelate suture-line, which, however, does not, as he supposes, distinguish this form from all other species of *Isocrinus*. LAUBE's figures bear enough resemblance to one of these specimens to enable it to be recognised, but are useless as illustrations of the species; fig. 20 *b*, for instance, must have been drawn from some other fossil, since the only joint-faces exposed on any of the specimens are syzygial. None the less the specimen identified does represent a distinct species found in the Cassian beds. A fragment of limestone from the Raibler beds of Ueberschall, Haller Anger, contains columnals referred to this species by WÖHRMANN (1889, Jahrb. Geol. Reichsanst. Wien, XXXIX, p. 192, pl. V, fig. 10). It is preserved in the Palaeontological Museum, Munich, where also is a similar but better fragment from Erlsattel near Zirl. A portion of the latter is now in the British Museum, registered E 7108. Neither of these fragments, however, contains anything that can properly be referred to *Isocrinus tyrolensis*. The Balaton district, on the other hand, has yielded several columnals which resemble LAUBE's specimens in many points. It is therefore necessary to precede their description by a redescription of the true *Isocrinus tyrolensis* from the origirial material, the specimen figured by LAUBE and here refigured (Pl. II, figs. 37, 38) being taken as lectotype.

Diagnosis of *Isocrinus tyrolensis* (LAUBE). — Transverse section quinquelobate. Height of internodals about one-fourth to one-third their diameter; or diameter taken as 100, height is from 22 to 37. Side-faces markedly convex at interradii, straight or slightly concave at radii. Surface smooth, except for occasional slight extensions of the intercrenellar grooves. Nodals not swollen. Suture-line crenelate all round. Internodals number 5—7.

Joint-faces. — Normal: lumen minute; petals regularly crenelate, with about 7 strongly marked peripheral crenellae to each; no radial space. Syzygial: depressed central area, stellate with radial extensions; floors concave in epizygal, convex in hypozygal; no trace of adradial crenellae, peripheral similar to normal but obscured and subconfluent; slight radial triangle, depressed.

Cirrus-facet confined to epizygal, deeply embedded in its distal half, facing straight outwards, slightly elliptical, surrounded by a slight rim; fulcral ridge about median, rather broad, narrowing towards lumen, which it surrounds. Cirral 1 scarcely projects, is more circular than the facet, and reaches nearer the syzygy; its outer face is directed downwards, and has a short, broad, fulcral ridge.

Further notes on holotype and paratypes. — Measurements in millimetres:

	Holotype	Paratypes			
Diameter	2·4	2·6	2·6	2·8	3·1
Length of *r*	1·1	1·1	1·2	1·2	1·25
Average height of internodals	0·9	0·6	0·6	0·7	0·69
Height of nodal	1·0	0·7	0·7	0·5	0·8

The statement concerning the side-faces applies to all specimens except one, in which they are concave all the way round. There is no such longitudinal ridge along the interradial angles as one would suppose from LAUBE's figures 20 *a* and *c*.

There is no great variation in the heights of the columnals of individual specimens, and this proves that the specimens are not from the proximal, less developed region of the stem.

Nodals occur on all the fragments except one, which comprises only 3 columnals, and of these one appears to be a hypozygal. In all the specimens one end is fractured at a syzygy, and in three of them both ends are. The number of internodals is 5 in the holotype, and 5, 5, 6+?, and 7+? in the other specimens. The inference from all these facts is that short internodes are characteristic of the species.

No normal joint-face is exposed, but the statements made in the diagnosis are inferred from the syzygial faces and the suture-lines.

The measurements of the cirrus-facet in the holotype are: tranverse diameter 0·5 mm., vertical diameter 0·45 mm. In one specimen the joint-face of the epizygal is deeply incised for cirri, and the indentation for the facet approaches the shape of a three-sided pyramid (compare the description of *Isocrinus tyrolensis major).*

We now proceed to discuss the remains of *Isocrinus* from the Balaton district.

Isocrinus tyrolensis major, subsp. nov.

(Pl. II, figs. 39—50.)

Diagnosis of the Subspecies. — Diameter of internodals absolutely much greater than in the type-form of the species, but height only slightly greater; therefore relative height tends to be less; if diameter = 100, height is 16 to 29. Number of peripheral crenellae in a petal more than in the type-form, viz. 8 to 14; relatively to the diameter also their number is greater and their thickness less.

Material. — The normal representatives of the subspecies are the following stem-fragments: 16 from the Quarry near Cutting I, Veszprem-Jutas Railway; 10 from the cutting itself; and 12 from Jeruzsálemhegy. Since these seem to indicate that the species attained a far larger size here than in the Tyrol, it seems advisable to give them a distinct subspecific name. The other diagnostic characters of the form may be regarded as following naturally upon this increase of size, so that, in all other respects, the description of the specimens provides a welcome supplement to the description of the typical *Isocrinus tyrolensis*. As holotype of the subspecies is taken the original of Pl. II, fig. 44.

Description of the Specimens. — Transverse section varies from a slightly excavate rounded pentagon (fig. 46) to a decided pentapetalon with almost semicircular lobes and sharper but rounded reëntrant angles (fig. 38). Excavation greatest at the epizygal. The stem-fragments being curved as a rule, the following measurements in millimetres are based on averages:

Diameter of internodals	2·2	2·8	3·1	3·4	3·9	4·0	4·0	4·1	4·3	4·3	4·4
Height » »	0·9	0·55	0·9	0·8	0·9	0·9	0·94	0·7	0·77	0·8	0·7
Ratio, height: diameter	2·4	5·0	3·4	4·25	4·3	4·4	4·25	5·85	5·58	5·37	6·28
Height of epizygal . .	0·9	0·9	1·0	0·9	1·1	0·9	1·0	0·8	1·0	0·95	0·8

The first of these, being young, has a ratio—diameter: height:: 100:43. This differs so greatly from the others that it is not included in the diagnosis. It agrees, however, with the rule that relative height decreases with age. Really, the second specimen, with its low internodals, is more aberrant, but probably comes from the proximal end of the stem and contains many freshly formed columnals.

Internodes short; out of 15 specimens, 10 have 5 internodals, and 5 have 6. Only in one case are there as many as 6 columnars following on the epizygal without clear signs of a hypozygal. The frequency of nodes is further proved by the large number of nodals in the collection; out of the whole 34 specimens, only 2 insignificant fragments show neither epizygal nor hypozygal. The fragments nearly always end at a syzygy, and in 15 out of the 34 they consist of a complete intersyzygium.

There is slight variation in the height of adjacent columnars. The nodals (order I) are about 0·1 mm. higher than the adjacent internodals. In an internode of 5 (fig. 44), the orders of size are arranged thus, beginning with the epizygal of the intersyzygium above: I, III, IV, II, IV, III, I. If there be 6 internodals (fig. 45), the added columnar appears to be the hypozygal, since the formula is now I, IV, III, IV, II, IV, III, I. These differences, though not always very apparent, are more pronounced than in the Tyrolese specimens, and are enough to confirm the view that those specimens cannot be merely younger forms. The differences of diameter and relative height between *I. tyrolensis* and *I. tyrolensis major* are therefore due, not to difference of age, but to absolute differences in size and mode of growth. The conditions of life in the Balaton district were perhaps more favourable to the growth of the species than were those at St. Cassian, and permitted the crinoid to grow larger more rapidly or to continue its growth to a greater age. The former alternative is supported by the small number of internodals, and is consistent with the observations of A. D. Mead *, who has shown that in *Asterias Forbesi* the rate of growth and the age of sexual maturity are entirely dependent on the food-supply.

Side-faces straight, with suture-lines scarcely depressed. In a few, and chiefly in the more excavate, there is a slight convexity, whereas in a few there is a slight

* Amer. Natural. XXXIV, p. 17; Jan., 1900.

concavity, which, however, may be due to weathering. Only one specimen, a fragment from Jeruzsálemhegy (fig. 41), approaches the shape characteristic of the typical *I. tyrolensis*, in that along the suture-lines in the reëntrant angles there are peculiar swellings, which make the side-faces concave radially, whereas they are slightly convex interradially. A sub-pentagonal specimen from the same locality also shows slight ridges along the sutures.

Nodals not more swollen than internodals.

Surface smooth.

Suture-line crenelate all round, except at the syzygies. Crenelation more pronounced at the interradial angles.

Joint-faces. — Normal: (figs. 39, 40) Lumen minute, subcircular or subpentagonal with interradial angles. Central area raised, continuous with radial ridge-groups. Petal-floors depressed, narrow, and either lanceolate or elongate petaloid, the greatest width being in their distal half. Radial ridge-groups of 2 to 5 pairs, of which the acentral crenellae, which are the larger, meet in a gable, while the adcentral ones lie straight across the radius. Peripheral crenellae in a petal vary in number, from 8 in a columnar of 2·2 mm. diameter, to 14 in one of 4 mm. diameter; the increase in number is correlated partly with the increase in diameter, partly with the greater depth of the radial excavation, since the nearer the section is to a pentagon, the more crenellae merge in the perradial series. The adradial peripheral crenellae requently meet at their outer ends, forming a gable. The peripheral crenellae diverge fan-wise from the interradius, sometimes straight, sometimes curving towards the interradius at their outer ends like the seven-branched golden candlestick. The crenellae widen towards their outer ends, but are never confluent. The following measurements in millimetres are taken from a normal columnal: diameter, 3·7; ength of IR, 1·85; length of *r*, 1·4; length of shortest crenella, 0·3; length of longest crenella, 0·6; width of crenella, 0·1.

Syzygial: Epizygal (figs. 42, 46), resembles normal joint-face modified as follows: radial regions raised as rounded ridges above the indented cirrus-facets (vide infra), broader towards the periphery, where the cirri emerge, and scarcely marked at all by crenellae; thus the rosette is more lobate, and the petals sometimes narrower, even adcentrally; peripheral crenellae also shorter, less distinct, and not so clearly separated from the petal-floors, so that each petal assumes a more hollow shape. Hypozygal (fig. 43), resembles normal joint-face modified as follows: lumen appears relatively large, pentagonal with radial angles, and probably comprises a depressed central area; petal-floors raised and swollen to fit into the hollows of the epizygal; radial spaces depressed to receive the radial ridges of the epizygal and the proximal cirrals, narrowing adcentrally into a slight radial groove, which runs right up to the lumen (or depressed area) and separates the adradial crenellae; crenellae faint, and continuous right round the petal.

Cirrus-facets (figs. 41, 42, 44—48). — Five on each nodal, in its lower part, indented in the radial re-entrant angles, to form deep, almost V-shaped excavations, abutting in either whole or part on the hypozygal, and indenting that also, though to a less extent. Thus, even in the least lobate columns, the epizygal is strongly lobate; but this can scarcely be detected from the side, since, owing to the depth of the indentation, the proximal cirrals are usually preserved, and all that is visible from outside is the joint-face of cirral 1 or 2. Removing these cirrals, one sees at the bottom of the V, and not far removed from the syzygial face, a minute lumen. Just above this is the fulcral ridge, which consists of two ledges, one running about half-way up each slope of the V, at whose apex they may or may not meet.

Th` shape of the facet is more easily understood by considering that of cirral 1. This is somewhat like a short cone flattened on one side The base of the cone is the joint-face for cirral 2; the flattened side abuts on the hypozygal the rounded side has a groove for the fulcral ridge of the facet to work in; above this comes the lumen, and then the cone slopes more rapidly to its apex. The distal joint-face (fig. 50) is transversely elliptical in outline, but bent transversely (i. e. cylindro-concave along the short axis); it also has a raised margin, and a short, stout fulcral ridge, below which as a rule is the lumen. The distal joint-face of cirral 2 (fig. 49) differs only in the accentuation of the marginal rim and of the ridge, and in the translation of the lumen to the centre of the fulcral ridge, which may be interrupted or continuous; the ridge and lumen are markedly supracentral. Details vary, but the ellipse, the rim, and the short stout ridge are constant.

A cirrus-facet approaching the triangular indentation just described was mentioned as occurring in one of the paratypes of *I. tyrolensis* (p. 32). Conversely in a few specimens of var. *major*, the facet has a more oval outline (fig. 48), and resembles the facet in the holotype of *I. tyrolensis* (pl. II, fig. 37). In such cases the whole facet is enclosed by the epizygal; but there is still an impression on the hypozygal, due to the raising of the epizygal joint-face in the regions of the cirri.

In all cases the proximal portions of the cirri have a slight downward direction.

The peculiar shape of the facet and its deep burial in the nodal render it more convenient to measure the outer joint-face of cirral 1; and this serves for comparison with the measurements of the actual facet in other species.

Diameter of stem	2·4	4·2	4·3	4·3	4·4	mm.
Width of side.	1·5	2·8	2·7	2·8	2·6	mm.
Width of facet of cirral 1 . . .	0·6	0·8	0·8	0·8	0·9	mm.
Height of facet of cirral 1 . . .	0·5	0·7	0·7	0·7	0·7	mm.
Length of cirral 2	?	?	0·2	0·3	?	mm.

Relations of the Subspecies to the type of the Species. — These have been partly discussed in connection with the height of the columnars. It will have been seen that, though the most tangible differences are those of mere size, yet, so far as the limited material permits any conclusion to be drawn, the direction of variation is different in the two forms. Thus, while *I. tyrolensis* normally has side-faces convex interradially and concave radially, *major* normally has straight side-faces; while *I. tyrolensis* normally has an elliptical cirrus-facet, *major* has a triangular indentation; and while *I. tyrolensis* normally has internodals of equal height, those of *major* usually vary according to their position in the internode. Although no accepted definition of a species would justify the specific separation of these two forms, yet the facts cause one to regard them either as distinct local races or as the one a mutation from the other. On the latter hypothesis *I. tyrolensis*, with its less specialised cirrus-facet, would naturally be regarded as the earlier in time; and since the later date of *major* is confirmed by external evidence, the view that this form is a mutation seems worthy of adoption. For this reason I have refrained from speaking of it as a «variety».

Outside the Balaton district, the only specimens that I have been able to refer to *I. tyrolensis major* are some from the Upper Cassian Beds between Verwies on the Falzarego road and Cortina. They are preserved in the Palaeontological Museum, Munich, under the name «*Pentacrinus tyrolensis*», and registered «1894, XIII, 231»; that Museum has kindly presented two of these fragments, an intersyzygium of 6 columnals in all and a series of 4 internodals, to the British Museum (registered E 7111).

Isocrinus tyrolensis var. α.

(Plate II, figs. 51—53, 55, 56.)

Material. — Six specimens do not quite agree with the diagnosis of either the species or the subspecies just described. They are: *a* and *b* from the Quarry near Cutting I on the Veszprém-Jutas railway; *c* and *d* from bed *e* in Cutting I; *e* and *f* from Jeruzsálemhegy. All are Raiblian.

a (figs. 52, 53, 55, 56) is an intersyzygium with four internodals including the hypozygal. *b* (fig. 51) is a single internodal. These two specimens resemble one another more than they do the others.

Description of Specimens. — Section markedly quinquelobate (*b*), or substellate (*a*).

Side-faces as in type of *I. tyrolensis*. Normal joint-face (seen in *b*) has raised area merging into adradial crenellae, of which there are about five on each side of a radial groove; they are not easily distinguished from the peripheral crenellae, which are well-marked and may be as many as 24 to the petal; petal-floors depressed. Epizygal joint-face has peripheral crenellae still well-marked, but longer and merging into the slightly depressed petal-floor. Hypozygal joint-face also has peripheral crenellae well-marked, but sub-confluent externally; an incipient radial triangle, but no radial groove; perradial crenellae long; petal-floors slightly raised. From two to four cirrals preserved in each radius. Distal face of cirral 3 shows sub-elliptical outline produced below, with rim pronounced except below, lumen supracentral, surrounded by a stout and very short fulcrum.

Measurements of *a* in millimetres: Diameter, 4·4; average height of columnar, 1·0; length of *IR*, 2·4; length of *r*, 1·4; transverse diameter of 3rd. cirral, 7·0; vertical diameter, 0·6 to 0·8.

c and *d* are intersyzygia, each with five internodals. Though laterally crushed they appear to have resembled *a* and *b* in transverse section and in number of crenellae.

e and *f* are intersyzygia, each with seven internodals. The syzygial faces are worn, but present a general agreement with those of *a*. The fragment *e* is not curved, but the sides of the internode along the interradial ridges are slightly concave. *f* is curved, and its side-faces closely resemble those of the holotype of *I. tyrolensis*. Measurements in millimetres:

	e	*f*
Diameter	3·5	3·8
Height of columnal . .	0·7	0·59

Relations of the Variety. — In the far greater lobation, the number of crenellae, the structure of the cirral joint-face, and minor points, these specimens present some obvious differences from both *I. tyrolensis* and its mutation *major*. In other characters, however, the resemblance is such that, if *a* and *b* alone were concerned, I should suppose them to come from the proximal part of the stem of *I. t. major*. But the number of internodals in *e* and *f* bars those specimens at any rate from such an interpretation. Only the accumulation of a larger number of specimens will enable us to decide whether this form represents a growth-stage, an individual variation, or a local variety of *I. tyrolensis major* — or possibly an independent mutation from *I. tyrolensis*, indicating divergent evolution.

Isocrinus tyrolensis var. β

(Plate II, fig. 54.)

Material. — A fragment consisting of three internodals, of which one is perhaps a hypozygal, from Cutting I on the Veszprém-Jutas railway, is doubtfully referred to this species. It is somewhat weathered, but not rubbed. Raiblian.

Description of Specimen. — Section scarcely lobate, rather sub-concavistellate.

Side-faces almost straight. Suture-line slightly depressed, and clearly crenelate all round. Ridges pass from the crenellae over the side-face, more markedly than in the holotype of *I. tyrolensis*, but, since the crenellae on one joint-face of a columnal do not quite coincide with those on its other face, these ridges are neither regular nor strictly vertical. They have perhaps been brought out by weathering.

A clean joint-face has been exposed by breaking away one of the columnals. Lumen minute, area and petal-floors flush, the latter not elongate. Radial ridge-groups consist adcentrally of small granules, but the perradial crenellae, about 4 in number, rapidly increase in length as they near the periphery and are sometimes curved in such a way that the distal gables, instead of being Λ-shaped, approach a λ shape (lambdoid). Peripheral crenellae about 8 to a petal

Measurements of a columnal: Diameter, 3.0 mm.; height, 0.8 mm.; *r* 1.4 mm.; ratio, — diameter: height:: 100: $26.\dot{6}$.

Relations of the Variety. — The flush area and petal-floors constitute the chief differences from the norm of *I. tyrolensis major*.

Isocrinus tyrolensis var. γ

(Plate II. figs. 57—60.)

Material. — There are seven stem-fragments from beds *a-b* of Cutting IV on the Veszprém-Jutas Railway, and one from bed *b* 1 of the same cutting. Raiblian.

Description of specimens. — All these closely resemble both the typical form of the species and the norm of mut. *major*, except in their smaller size, as shown by the following measurements in millimetres.

Diameter	1·2	1·3	1·5	1·7	1·8	1·9	2·1	2·1
Height of internodal	0·5	0·6	0·45	0·36	0·6	0·44	0·43	0·5
» » epizygal	0·4	0·5	0·4	0·4	0·65	0·5	0·4	0·8
Diam.: 100:: height of internodal:	41·0	46·0	30·0	21·0	33·0	23·0	20·0	24·0

The average ratio of height to diameter is 29·75:100, which is nearly the same as in the type-specimens of *I. tyrolensis.* Section a pentapetalon, becoming strongly lobate at the epizygals, so as to resemble that of var. *α*

Number of internodals, 5.

Joint-faces. — Normal, not well preserved, and adradial crenellae not distinguished; peripheral crenellae few, about 6 or 7. Epizygal, raised peripherally and centrally, but not radially, peripheral crenellae obscured, subconfluent, 10 to a petal. Hypozygal, raised peripherally, but petal-floors very slightly raised; radial depression short and not passing to central area.

Relations of the Variety. — Had these specimens been found in association with *I. tyrolensis* or even with its mutation *major*, one would probably have considered them merely as having belonged to young individuals, in spite of certain objections. But since they occur isolated, those objections gain force. The relative shortness of the epizygals, and the absence of marked variation in the heights of adjacent columnars, as well as the invariable number of 5 internodals, are not characters of youth, but suggest that the specimens may represent a dwarf variety.

Isocrinus candelabrum n. sp.

(Plate III. figs. 61—76.)

Diagnosis. — Transverse section varies from sub-concavi-stellate, through slightly quinquelobate and subpentagonal, to subcircular. Height of internodals about one third their diameter in adult to one half their diameter in younger stages; or diameter taken as 100, height is from 27 to 52 (average 40). Side-faces smooth, straight, sometimes slightly concave, slightly convex, or slightly sinuous; interradial angles of epizygal tend to be swollen at half their height. Suture-lines flush, crenelate all round, except at syzygies.

Joint-faces. — Normal: lumen minute, subcircular or subpentagonal, central area raised, wide, continuous with perradial crenellae; petal-floors very narrow and rather short; radial ridge-groups of one or two or three pairs, according to size, the adcentral pair usually merged in an indistinct straight ridge at right angles to the radius, the acentral pair meeting at rather less than 90°; peripheral crenellae long, from 5 to 8 in a petal according to size, curving from the interradius to the periphery like the branches of a seven-branched candlestick, widening slightly, but in no degree confluent. Syzygial: lumen larger; epizygal a pentapetalon with a slight indefinite rim and scarcely a trace of crenellae; hypozygal, margin markedly raised at radial re-entrant angles, less raised around petals, radial spaces sometimes slightly raised, petal-floors may be slightly raised, but if not, then the whole petal appears slightly concave; between the narrow floors and the periphery are faint traces of the long radiating crenellae.

Cirrus-facet deeply indented in lower half of epizygal. Distal face of cirral 1 flush with columnar side-face, transversely elliptical, almost circular; rim stout; fulcrum, surrounding lumen, rises gradually from floor, more steeply on upper slope so that the lumen is supracentral.

Material. — The following specimens have been studied: 16 stem-fragments from Cserhát (Leitnerhof) lettered *a-p*; 1 internodal from Jeruzsálemhegy, lettered *q*;

1 internodal from bed *e 4* of Cutting VI on Veszprém-Jutas Railway, lettered *r*; an internodal (*s*) a hypozygal (*t*), a hypozygal with one other internodal (*u*), and a hypozygal with two other internodals (*v*), all from Veszprém, Giricses Domb, lower stratified limestone. Specimen *c* (figs. 62—64) is taken as holotype.

With the exception of *q*, all these specimen are of Cassian age. Specimen *q* is Raiblian, and, as will be seen, shows slight differences from the others, so that perhaps it does not really belong to this species.

Description of Specimens. — The variation of the transverse section (figs. 62, 65 69) occurs between individual specimens, but also no doubt between regions of the same stem; the excavation is greatest at the epizygal as usual.

The following measurements in millimetres are of ordinary internodals, except where otherwise stated, and are based on averages where possible.

	a hypoz.	*b* hypoz.	*b* epiz.	*c*	*c* epiz.	*d*	*e*	*f* hypoz.	*g*	*g* epiz.
Diameter	1·5	1·35	1·6	2·3		2·5	2·7	2·7	2·8	
Height	0·75	0·7	0·9	1·05	0·9	1·24	0·9	1·0	0·9	1.1
Diam. 100, height = . . .	50	52	62	46		50	33	37	32	

	h	*i*	*j*	*j* hypoz.	*k*	*p*	*p* hypoz.	*p* epiz.	*q*
Diameter	2·9	3·0	3·0		3·0	3·1			3·3
Height	1·0	1·2	1·0	0·9	0·83	1·2	0·8	1·3	0·9
Diam. 100, height = . . .	34	40	33		28	38			27

From this it appears that relative height tends to decrease as diameter increases, that epizygals tend to be higher and wider than ordinary internodals, and hypozygals lower.

Except for the nodals, variation in the side-faces is confined to different specimens. The greatest divergence from approximate straightness occurs in *p*, where the side-faces of the ordinary internodals are markedly concave; the diameter at the suture being 3·1 mm., that in the middle of the columnal is 2·9 mm. In the same specimen the side-faces of the hypozygal are slightly concave, those of the epizygal almost straight.

On internodal suture-lines the crenellae are equally pronounced all round, but at the syzygies they are scarcely visible.

There is slight variation in the height of adjacent columnars, the most widely separated extremes observed in any single specimen being 1·0 mm. and 0·6 mm.; but the material is not enough to permit of any inference.

The only complete intersyzygia are *l*, *m* (fig. 61), *n*, and *p*. These specimens probably belong to this species, but without seeing a normal joint-face, one cannot be absolutely certain. Some of them may be *Isocrinus tyrolensis*. They have respectively 5, 5, 4, and 4 internodals including the hypozygal.

The eleven other specimens from Cserhát include three fragments with epizygals, and four with hypozygals, while the remaining four are single internodals. In two cases there must have been at least five internodals including the hypozygal. The evidence of these and of the other specimens, as given above, suggests that the number of internodals was 5 or 4, and that the stems broke readily on the normal joints, as one might expect from the small size of the interradial ligament-scars or petal-floors. The length and composition of the fragments is in fact due to structure rather than to conditions of preservation, and may be regarded as a diagnostic character.

Joint-faces. — Normal (fig. 68): the petal-floors are shortened by the encroachment of the raised central area, while they are not merely narrowed, but also ill-defined, through a similar encroachment of the crenellae, which die away into the floors. Sometimes the petal-floors appear depressed slightly, but sometimes, as in *q*, they are slightly raised; in this respect also their instability is manifest. Of the peripheral crenellae the adradial are as usual the longest, and those of adjacent petals may meet on the periphery; the crenellae radiate from a point about the centre of the petal-floor, and curve upwards towards the interradius as they near the periphery, thus diminishing the number of perradial crenellae; they number 5 to a petal in a columnar 1·6 mm. in diameter, and 8 to a petal in columnars of 2·3 mm. to 3·0 mm. diameter; in *q*, with a diameter of 3·3 mm., an incipient 9th is seen on some of the interradii.

The following are measurements of normal joint-faces in millimetres:

	j	*q*
Diameter	3·0	3·3
Length of *IR*	1·5	1·7
Length of *r*	1·4	1·6
From centre to end of petal-floor	1·3	1·1
Length of shortest crenella	0·2	0·6
Length of longest crenella	1·0	0·9
Width of crenella	0·1	0·13

Syzygial (figs 62, 65, 69, 73): in *p* the lumen of the epizygal appears to have radial angles, while that of the hypozygal at the other end of the fragment has interradial angles as usual. There is nothing else to add to the account in the diagnosis.

The cirrus-facet (figs 61, 63, 64, 71, 72) abuts on, but scarcely indents, the hypozygal. In other respects it seems to have resembled that of *Isocrinus tyrolensis major*, though the triangular pyramid is not so clearly marked. The joint-faces of the proximal cirrals also resemble those of that form, though the section is perhaps more circular, and the fulcrum a trifle stouter. The proximal cirrals appear to have turned downwards in *l*, but upwards in *p*. The following are measurements in millimetres of the distal joint-face of cirral 1:

	c	*g*	*p*
Side of column	1.5	1·7	2·0
Long diameter of facet	0·6	0·8	0·6
Short diameter of facet	0·5	0·7	0·6

Relations of the Species. — In many respects the species resembles *Isocrinus tyrolensis* and its mutation *major*, but the points of difference are persistent. These are chiefly: less excavation of radial angles; greater absolute height of internodals, with a relative height twice as great; the narrow and indistinct petal-floors, correlated with longer crenellae; the curvature of the adradial crenellae and consequent decrease of radial ridge-groups; the simpler, i. e. more specialised, syzygies, especially as regards the almost total atrophy of the crenellae, without any concentration of them, so that the syzygial suture-line is not crenelate. These characters are inconsistent with the view, which the smaller average diameter might suggest, that the specimens are the young of mut. *major*.

The arrangement of the crenellae approaches that of «*Pentacrinus*» *venustus*, but the perradial crenellae are more distinct, and of course the cirri are quite different. The large crenelate areas and small petal-floors may be regarded as primitive. The peculiar curvature of the crenellae, with its resemblance to the seven-branched golden candlestick, has suggested the name *candelabrum*.

Intercalation of fresh Columnals in Young. — Specimen *o* from Cserhát consists mainly of an epizygal and two internodals (fig. 70). The epizygal face is markedly lobate, but that of the internodal is between subcircular and sub-pentagonal. The diameter is 1·1 mm.; the height of an internodal 1·0 mm.; the height of the epizygal 0·7 mm. The great relative height of the columnals, due to the youth of the specimen, is, however, discounted by the fact that fresh columnals are being formed between them. They do not appear regularly all round, but that between the two internodals is in two lenticular masses, about 0·7 mm. high, on one side of the stem, while that above the epizygal is a smaller mass, 0·4 mm. high, on the other side. The joint-faces are obscure and do not seem to have a definite rosette.

Preservation of Axial Nerves. — Specimen *p*, also from Cserhát, is perhaps the most interesting of all the Echinoderm fossils described in this memoir. It is a complete intersyzygium of subcircular section, with five internodals. The surface is pitted in places, possibly by some boring organism. The measurements and other details have already been given.

The interest centres in the joint-faces. In the hypozygal (figs. 73,74, text-fig. 5 *A*) the lumen is somewhat quinquelobate, with interradial angles, and a diameter of 0·77 mm. The calcite filling it is much darker than the stereom of the ossicle. In it are six specks, invisible when wet but conspicuously white when dry, arranged with one in the centre and the others regularly disposed around it. This system, which has a diameter of about 0·25 mm., is shifted a little from the centre of the lumen towards one of the angles, but the 5 surrounding spots appear to have been interradial in position. Some of the spots appear to be joined to the central one by a narrow band. It was obvious from the first that this system represented the central vascular axis and the five prolongations of the chambered organ as they are found in all living crinoids (see for instance P. H. Carpenter, Challenger Report, Stalked Crinoids, pl. XXIV, ff. 1—5); but if the five surrounding specks were to be regarded as the canals prolonged from the chambered organ, then their interradial position was perplexing. Indeed this fact threatened my argument as to the relations between the aboral nervous system and the base,* and with it the main division of the Crinoidea into Monocyclica and Dicyclica.**

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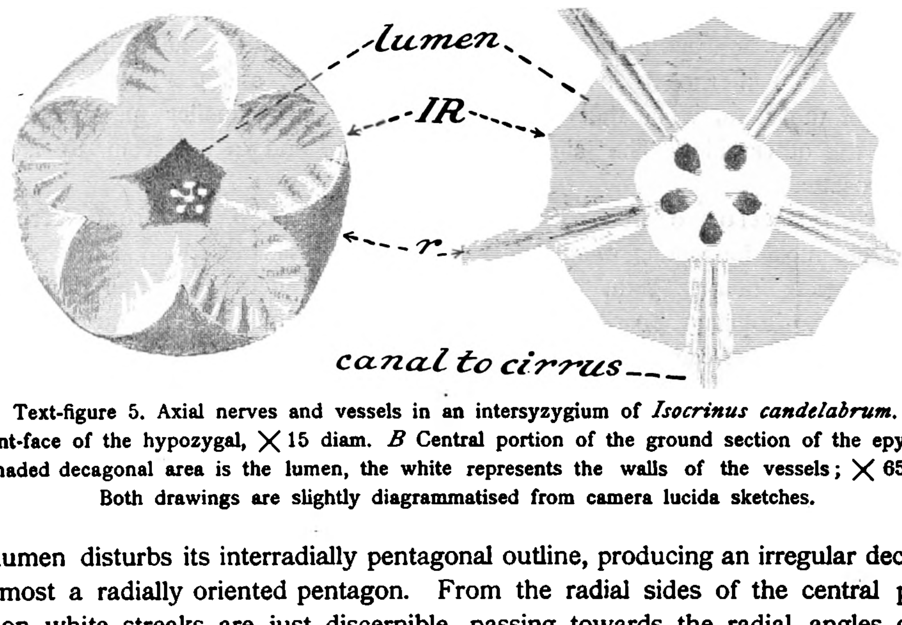
* See «Third Notice of Wachsmuth & Springer's Monogr.» *Geol. Mag.*, dec. IV, vol, V, pp. 422—426; Sept., 1898.

** See Bather, «The Echinoderma» pp, 104, 111, 142, Vol. III in «Treatise on Zoology» ed. E. R. Lankester; 1900.

At first I was unable tc detect any traces of this system on the epizygal face; but by gradually grinding it down and treating it with glycerine and alcohol, certain structures became visible through the microscope under a penetrating light (fig. 75). On grinding down to the level of the cirrus-lumina these structures became clearer, as I had anticipated, and revealed their true nature (text-fig. 5 *B*). In the centre of the lumen is a tiny white pentapetalon, with slightly marked lobes, interradially placed. Radially situated within the pentapetalon are five ovoid spaces, which are now darkened by the infilling calcite, but represent canals in the living animal — in fact the radial prolongations of the chambered organ. Hence it follows that the white specks seen on the hypozygal face represent, not the canals, but the thickened walls between them. There was no doubt a central canal, but too minute to be visible, so that its walls appear as a solid white mass.

The ground section of the epizygal (fig. 76) shows the canals of the cirri passing to the columnar lumen, and swelling out as they pass across the joints between cirrals 1 and 2, and between cirral 1 and the columnar. Their entry into



Text-figure 5. Axial nerves and vessels in an intersyzygium of *Isocrinus candelabrum*. *A* joint-face of the hypozygal, × 15 diam. *B* Central portion of the ground section of the epyzygal; the shaded decagonal area is the lumen, the white represents the walls of the vessels; × 65 diam. Both drawings are slightly diagrammatised from camera lucida sketches.

the lumen disturbs its interradially pentagonal outline, producing an irregular decagon, or almost a radially oriented pentagon. From the radial sides of the central pentapetalon white streaks are just discernible, passing towards the radial angles of the lumen. These may represent in part strands of connective tissue, specially needed to support the central axis at its nodal swelling, and in part the walls of the nerve-canals to the cirri.

These remarkably preserved structures afford interesting confirmation of the conclusions already derived from sections of the stem in the recent *Isocrinus*, as to the radial position of the prolongations of the chambered organ (proving the primitive possession of a dicyclic base), while the interradial direction of the angles of the lumen is seen to have been produced, probably by secondary formation of stereom, even at that early period. It has only been by repeated examination that I have succeeded in elucidating them, so that no time has been left in which to carry the research further. Traces of the same structures are however to be detected in the large specimen *I*, and I have no doubt but that their preservation will prove to be not so very uncommon.

Isocrinus scipio n. sp.

(Plate III, figs 77—89,)

Diagnosis. — Transverse section varies from subcircular, through subpentagonal and quinquelobate, to stellate; the last, however, being only in the syzygial region. The majority are slightly quinquelobate. Extremes of diameter observed, 1·1 mm. and 2·7 mm. Height of internodals rather more than one-third their diameter in adult to more than four-fifths their diameter in younger stages; or diameter taken as 100, height is from 34 to 83 (average 57). Side-faces smooth, straight, slightly convex, or slightly concave, and sometimes with incipient radial pores; interradial angles of epizygal swollen into rounded ridges, which rise towards the syzygy and thence die away into the hypozygal. Suture-line flush or slightly raised, crenelate all round, except at syzygies. Internodals usually 5, may be 4.

Joint-faces. Normal: lumen minute, subcircular to pentagonal; central area very slightly raised, vermicular, reaching perradial crenellae, but not merging in them, occasionally indistinguishable, especially in smaller specimens; petal-floors flush, pyriform, with straight sides and semicircular ends; radial ridge-groups of one or two pairs, of which the adcentral pair may fuse into a relatively conspicuous radially directed ridge, while the components of the acentral pair either meet at an angle or are themselves fused with the ridge; peripheral crenellae 4 to 7 in a petal, according to size, usually 5, regularly arranged and differing but slightly in length, clean-cut and distinct. Syzygial: scarcely a trace of crenellae; convexities and concavities of the usual type, except that the hypozygal is often slightly concave interradially.

Cirrus-facet at the truncated end of a subconical depression, which lies in the lower two-thirds of the epizygal and cuts into the hypozygal slightly; it is very slightly elliptical with a faint rim and broad fulcrum. Distal face of cirral 1 flush with columnar side-face, slightly transversely elliptical; rim distinct, may be doubled at upper margin; muscle-fields excavate; fulcrum just above centre, separate from rim, and tapering to centre, where the lumen lies below it.

Material. — This is the commonest species at Cserhát (Leitnerhof), there being no less than 473 stem-fragments from that locality. There are also referred here 22 stem-fragments from Veszprém, Giricses Domb, lower stratified limestone, and one doubtful crushed fragment, consisting of three columnals, from bed *e* of cutting VI on the Veszprém-Jutas railway. All these are of Cassian age.

The description and measurements are based on 49 specimens selected from the Cserhát lot to represent the different diameters; and from these 11, lettered *a* to *l*, have been chosen for figuring. No single specimen shows all the diagnostic characters, but *d* is hereby selected as holotype.

Description of Specimens. — The following measurements in millimetres are based on averages of the columnals:

Diameter	1·1	1·1	1·2	1·4	1·4	1·4	1·6	1·7	1·7	1·8
Height of internodal . .	0·8	0·9	1·0	0·9	0·97	1·1	0·83	0·98	1.05	0·97
Height of epizygal . . .	—	0·9	1·0	0·9	1·0	1·0	0·9	1·0	0·9	1·01
Diam. 100, height. = .	72	81	83	64	69	78	52	57	61	54

Diameter	1·8	1·8	1·9	1·9	1·9	2·0	2·2	2·5	2·5	2·7
Height of internodal . .	1·05	1·1	0·9	1·06	1·07	0·96	0·75	0·86	1·0	0·96
Height of epizygal . .	1·1	—	0·8	0·8	1·0	1·0	0·9	1·0	—	1·0
Diam. 100, height = . .	58	61	47	55	56	48	34	34	40	35

The average of 22 specimens, with diameter taken as 100, gives the height of an internodal as 57, the mean between the extremes being 58·5.

The internodes are short; out of 16 specimens taken at random 6 had four internodals, and 10 had five, the hypozygal being reckoned in each case. Fracture at the syzygy is fairly frequent, but there are some cases in which the syzygy remains unbroken, with its suture-line scarcely discernible (fig. 82), while on the other hand there are many isolated columnals.

There is very little difference in size between the internodals; but the hypozygal in usually the shortest.

The swelling of the epizygals, though manifest to the naked eye (fig. 80), results in a very slight increase of diameter, since it is partly compensated by the much greater radial excavation of these columnals. Thus, in a fragment with an internodal diameter of 2·7 mm., the diameter at the syzygy is only 2·75 mm., an increase of less than 2 per cent.

The sculpture of the normal joint-faces (figs. 77—80) is clear-cut, and the crenellae surround the petal regularly, with little variation in size; the interradial peripherals are as usual the shortest, while the adradial peripherals are the longest, and are parallel to those of the radial ridge-groups. The following are measurements of a normal columnal in millimetres: diameter, 2·0; *IR*, 1·2: *r*, 0·8; from centre to end of petal-floor, 0·85; longest crenella, 0·4; shortest crenella, 0·2 or less: width of crenella, 0·1. The crenellae may widen, almost imperceptibly, towards their outer ends, but are not confluent.

The epizygal face (figs. 81, 88) is raised radially and is concave interradially. The appearance varies in intensity, and also with the extent of the lobation; but no essential difference arises. The hypozygal face (figs. 84, 87) is as a rule somewhat flatter than that of the epizygal; sometimes the petal-floors are raised as usual in the genus, but they are often slightly concave.

Although the depressions for the cirri cut slightly into the hypozygal, the cirrus-facet itself is wholly in the epizygal (figs. 82, 83, 85, 86, 89). The position of the lumen has not been made out. On the distal face of cirral 1, the dice-box-shaped fulcrum, with the lumen below it, appears to be characteristic. The following are measurements of a normal example in millimetres: diameter of epizygal, 2·7; width of side, 1·9; transverse diameter of facet, 0·8; vertical diameter of facet, 0·7; length of fulcrum, 0·4. There is no trace of further cirrals.

Relations of the Species. — In side-view it is not easy to distinguish the larger specimens from *I. candelabrum*. The relative height of the columnals, when all are considered, is greater than that of any other species from this district; but size for size it about equals that in *I. candelabrum*. There are, however, too many differences between the two species to allow one to suppose that *I. scipio* is merely the young of *I. candelabrum*. The swelling of the epizygals is more marked and approaches that of *I. sceptrum*, from which it is distinguished by the many features subsequently detailed. The vermicular area, the radially directed adcentral perradial crenellae, and the whole rosette are quite distinct from those of *I. candelabrum*.

The appearance of the smooth, high internodals, surmounted by the swollen and indented nodal, has suggested the trivial name, from *scipio*, a truncheon or baton of office.

A patina, doubtfully referred to *I. scipio*, is described *infra* (p. 56).

Isocrinus sceptrum n. sp.

(Plate IV, figs. 90—101.)

Diagnosis. — Transverse section slightly quinquelobate at intervals, but may approach subpentagonal or even subcircular; more stellate at syzygies. Extremes of diameter observed, 1·0 mm. and 2·8 mm. Diameter of internodals taken as 100, height varies from 80 to 30, the average of 22 specimens being 46·5. Nodals slightly higher than internodals, and hypozygals about $^3/_4$ height of adjoining internodals. Side-faces concave, especially radially, but sometimes raised again at half the height, usually only in the radial hollows, and so tending to scalariform. Radial hollow of epizygals sharper and deeper, interradial angles projecting as narrow rounded ridges, arcuate in side-view, not extending over hypozygals, which, however, are slightly excavate radially. Suture-line raised, crenelate all round, sometimes beaded. Internodals 5 to 8, usually 6.

Joint-faces. Normal: lumen minute, subcircular or subpentagonal; central area slightly raised, vermicular, reaching perradial crenellae but not merging in them; petal-floors flush, pyriform, with straight sides and regularly arched ends; radial ridge-groups frequently only one pair, at an angle of 60°, enclosing a slight hollow; adcentrally may be added a single transverse ridge, which in small specimens may alone be present; acentrally in large specimens may be added another pair at an angle of 60°; peripheral crenellae 3 to 7 in a petal, according to size, regularly arranged, and differing but little in length, short, stout, clear-cut, and distinct. Epizygal: markedly quinquelobate, approaching stellate, with the interradial ribs of the side-face appearing as points to the star but not entering the joint-face; petal-floors smoothly and gently excavate, meeting in radial ridges; no perradial or adradial crenellae; peripheral crenellae short and low, but often distinct, number 7 or 8 in a petal. Hypozygal: surface almost smooth and plane, with very slight radial depressions, and the barest traces of crenellae.

Cirrus-facet flush or slightly raised, in lower half of epizygal, reaching nearly to its lower margin; transversely elliptical; rim distinct; lumen central, sometimes with rim; fulcrum as two tubercles, above transverse diameter, sometimes elongated at an angle of 60° thereto and converging upwards.

Material. — Stem-fragments of this species have been received in greater abundance than any other, whether it be that a colony was chanced upon or that it really is the commonest crinoid of the Veszprém district. Nearly all come from Cutting VI on the Veszprém-Jutas railway. Of these about 7855 specimens were labelled as from bed *e* 4, and eight of them as from bed *e* without distinguishing numeral. Four specimens were subsequently sent by Professor Laczkó from Veszprém-Vamu, Csösz Domb, and one from Veszprém, Giricses Domb, lower stratified limestone.

The 10 normal specimens figured (figs. 90—100) are all from bed *e* 4 of Cutting VI, and the original of fig. 94 is taken as holotype.

All are of Cassian age.

Description of Specimens. — The following measurements in millimetres are based on averages of the columnals:

Diameter	0·8	1·0	1·15	1·2	1·3	1·5	1·5	1·6	1·6	1·65
Height of internodal .	0·56	0·8	0·75	0·6	0·75	0·7	0·86	0·72	0·76	0·8
Height of epizygal . . .	—	—	0·75	—	0·8	0·9	0·95	0·9	0·9	—
Diameter 100, height = .	70	80	65	50	57	46	57	45	47	48

Diameter	1·7	1·8	1·8	1·9	1·9	2·1	2·2	2·3	2·8
Height of internodal . .	0·8	0·64	0·73	0·8	0·87	0·76	0·8	0·83	1·0
Height of epizygal . . .	0·9	0·9	—	0·9	1·1	—	—	—	—
Diam. 100, height = . .	41	30	40	42	45	36	36	36	35

The sculpture of the side-face (figs. 94, 95) is neat and very characteristic. The fine sutural ridge often bends in and out with the crenellae, and so tends to produce a double row of beads. The most pronounced feature, however, is the raising of the interradial angles of the epizygal as narrow rounded ridges, which project in a bow-like curve well beyond the general level of the column; between them is the broad, deep, and sharply marked radial excavation, in which is set the distinct and slightly raised cirrus-facet (cf. figs. 97, 98). An intersyzygium, held with the epizygal uppermost, reminds one of a jewelled staff surmounted by a regal crown. Thus the trivial name *sceptrum* conveys not merely this idea, but also the idea of superiority over the truncheon — *scipio.*

The extent of the nodal swelling appears from these measurements in millimetres:

Diameter of internodal	1·6	1·5
Diameter of nodal	1·8	1·7
Height of internodal	0·72	0·86
Height of nodal	0·9	0·95

The increased radial excavation also affects the hypozygals, but to a far less extent, while they show no trace of the interradial ridges.

Out of 13 fragments taken at random, 3 have 5 internodals, 6 have 6, 3 have 7, and one has 8. The fragments are broken at every syzygy, but many are broken elsewhere; there are many without either epizygal or hypozygal.

Joint-faces. — Normal (figs. 91—93): the longest crenellae are the adradial peripheral, which, in large specimens, may become perradial. The crenellae scarcely widen towards their outer ends. The following measurements in millimetres are from a normal internodal: diameter, 2·3; length of *IR*, 1·2; length of *r*, 1; from centre to end of petal-floor, 0·9; length of shortest crenella, 0·2; length of longest crenella, 0·4; width of crenella, 0·075. Syzygial (figs. 97—100): the increased number of peripheral crenellae at the syzygy is due to the greater radial excavation; the whole syzygial suture-line is crenelate.

The position of the cirrus-facet on the deep radial excavation seems to have done away with the need for any special excavation of its own. The articular surface (fig. 96) is therefore comparable with the distal face of cirral 1, in such species as have that cirral deeply sunk. No cirrals are preserved. The following measurements in millimetres are from characteristic nodals:

Diameter of nodal	2·2	1·9	1·8
Width of its side	1·3	1·15	1·3
Transverse diameter of facet . . .	0·9	0·6	0·75
Vertical diameter of facet	0·5	0·4	0·45

Abnormal specimen. — (Pl. IV, fig. 101.) One of the eight fragments from bed *e* of Cutting VI on the Veszprém-Jutas Railway consists of one complete internodal and the greater part of another. It presents several peculiarities. Transverse section strongly quinquelobate, almost stellate. Diameter and height, both 1·4 mm., this ratio being quite exceptional in *Isocrinus*. Side-faces slightly depressed on the interradial angles at half the height, suggesting fusion, or possibly incomplete separation, of two columnals. Suture-line crenelate all round, but there are radial pores. Normal joint-face (subsequently broken) though rather worn showed a pattern generally similar to the norm, with at least eight peripheral crenellae in each petal; but a radial canal passed from each pore to a rim round the lumen, so that the adradial crenellae did not form gables. Possibly the specimen came from the proximal region of a stem. Among the normal specimens there is only one face so stellate, and that one is epizygal.

Relations of the Species. — The abundance of material enables one to found this species with considerably more confidence than some. It is besides remarkably well characterised. No doubt it is closely related to *Isocrinus scipio*, and it is possible that here and there a worn or ill-preserved specimen may have been confused. The measurements of the two species appear much the same; but, taking a large series, one notes that in *I. sceptrum* the relative height of the internodals is less, while the epizygals are higher than the internodals, and the hypozygals lower, more constantly and to a greater degree than is the case in *I. scipio*. While five is the maximum number of internodals observed in *I. scipio*, it is the minimum in *I. sceptrum*. The syzygial union appears to have been firmer in *I. scipio*. The joint-faces of the two species are very similar, but the radial direction of the adcentral perradial crenella has not been observed in *I. sceptrum*, and the crenelation of the syzygies is less. All these are small points, but not without significance. It is however, in the sculpture of the side-faces that the differences are most obvious, and especially in the nodals. The interradial ridges of these ossicles are finer and more pronounced in *I. sceptrum*, while they do not pass on to the hypozygals as in *I. scipio*. The cirrus-facets also are different.

Considering the species without reference to the localities and beds from which the specimens have been obtained, one would regard *I. sceptrum* as descended from *I. scipio*, and as more specialised than it. *I. scipio* seems to be more advanced than *I. candelabrum*, which I am inclined to consider as the most primitive of the true *Isocrini* from this district. All three species, however, are found on the same horizon.

Isocrinus Herucuniae * n. sp.

(Plate IV. figs. 103—112, Plate V., figs. 113—117.)

Diagnosis. — Transverse section varies from pentagonal, through stellate and concavistellate, to quinquelobate with shallow re-entrant angles; the lobation is greater in columnals just above the nodes; in a few the section departs from concavistellate by a slight radial convexity. Diameter observed to range from 2·5 mm. to 7·2 mm. Diameter being taken as 100, height of internodals is from 32 to 13; mean of extremes 22·5; average of 20 specimens, 21. Nodals nearly half as high again as internodals, and hypozygals slightly higher than adjacent internodals. Side-faces smooth, slightly convex or, in basaltiform columns, almost straight; nodals not swollen. Suture-lines depressed, especially in re-entrant angles, where is a cavity; crenelate only at interradial angles, and that obscurely. Internodes long (as many as 14 internodals observed).

Joint-faces. Normal: lumen minute, subcircular; central area raised, usually smooth, merging into perradial crenellae; petal-floors sunk, smooth or granulate, lozenge-shaped to lanceolate, with short diameter at half the distance or nearer the centre; radial ridge-groups vary from crenellae, which inosculate or meet gablewise, to granules, which become regular and may fuse into two ridges radially disposed, or into a series of ridges at right angles to the radius, or into reversed gables; peripheral crenellae vary in length inversely as the radial excavation, vary in number from 6 to 15 according to size of columnal and depth of radial excavation, subconfluent, diverge from interradius either parallel or fan-wise; a marginal rebate broadening into a radial triangle with obtuse apical angles and with base often raised perradially into a lip. Syzygial: as usually seen, resemble normal joint-faces with the sculpture less accentuated; but in some (perhaps all if well preserved) the original sculpture is overlaid by a fresh series of very fine crenellae all round each petal; epizygal radial triangle reduced or absent, petal-floors sunk as usual; hypozygal petal-floors gently swollen.

Cirrus-facet occupies whole height of nodal, sometimes indenting hypozygal and supranodal, about flush, directed very slightly upwards; transversely elliptical with well-defined rim, tending to be flattened below and somewhat compressed at ends; fulcrum well above centre, swollen at ends and around lumen, and sometimes grooved.

Material. — This species is abundant and widely dispersed within the Veszprém district. The greater part of the material, over 400 stem-fragments, with some pieces in matrix, comes from the quarry near Cutting I on the Veszprém-Jutas Railway. The 14 specimens figured, lettered *a*—*o*, are all from this locality. There are also 8 fragments, of which the bed is not stated, from Cutting I; 2 fragments from bed *e*, Cutting I; and 47 fragments from Jeruzsálemhegy. From Cserhát (Leitnerhof) there come a nodal, with three of its cirrus-facets worn off, and two internodals, apparently rolled; but these specimens are doubtful. One ill-preserved columnal occurs in a small piece of limestone from Kökepalja near Veszprém, Cutting VII, bed *d* 1, while a similar specimen is labelled «Veszprém, Lanczi». Specimen *a* (figs. 102, 103), from the quarry near Cutting I, is taken as holotype.

* *Hercunia*, the ancient name of Bakony.

The beds at the first three localities are of Raiblian age, Those at Cserhát are Cassian, a fact which throws further doubt on the identity of the speciemens from there. I have no further evidence as to the age of the beds at Köképalja and Lánczi.

Description of the Specimens. — Although *Isocrinus Hercuniae* is clearly characterised, yet the very multiplicity of characters, combined with their wide variation, has rendered it difficult to combine lucidity with brevity in the above diagnosis. It is therefore advisable to repeat the statements in the following full description.

Transverse section (fig. 117) may be a pentagon, a star, a slightly excavate star, a rounded star, or a slightly marked pentapetalon. The excavation and the rounding of the angles are greater in columnals just above the nodes; excavation may also have been greater in the proximal region of the stem; but some columns as a whole may have been more excavate than others, for the extent of excavation and lobation do not seem to vary with the diameter of the columnals. In a few cases the concavity of the sides, in what would otherwise have been a slightly excavate star, is interrupted by a slight radial elevation (fig. 104).

One stellate fragment, of four columnals, is regularly hexagonal.* (Pl. IV, figs. 106, 107).

The following measurements in millimetres are taken from normal internodals:

Diameter	2·5	2·8	2·8	3·3	3·5	3·5	3·8	3·8	4·2	4·3
Height	0·8	0·9	0·65	0·8	1·0	0·7	1·0	0·9	0·9	1·1
Diam. = 100, height = .	32	32	23	24	28	20	26	23	21	25
Diameter	4·3	4·5	4·5	4·7	5·2	5·3	5·4	6·1	6·6	6·7
Height.	0·7	0·8	0·7	0·96	0·9	0·9	1·0	1·0	1·2	0·9
Diam. = 100, height = .	16	17	15	20	17	17	18	16	18	13

The following are measurements of nodals in millimetres:

Diameter	3·9	4·5	4·6	4·9	5.3	5·4	5·7	6·2	7·2
Height	1·0	1·3	1·2	1·2	1·4	1·3	1·5	1·5	1·5
Diam. = 100, height = . . .	25·6	28	26	24	26	24	26	24	20

* This is a very rare occurrence. P. H. Carpenter (Challenger Report, Stalked Crinoids, p. 38) says: «In all the Pentacrinidae there are invariably five rays. I have never met with any exception to this rule». In an Appendix on «Sudden Deviations from Normal Symmetry, chiefly in ‚Neocrinoidea',» (*Quart. Journ. Geol. Soc.* XLV, p. 168; Feb. 1889), I was able to quote five examples of deviation from pentamerism in *Isocrinus* and two in *Balanocrinus;* but all these were four-rayed. Tetramerous stem-fragments of *Isocrinus* have also been figured by M. R. Rosinus (Tentaminis de Lithozois ac Lithophytis, Tab. V, Classis H, ff. 1—4; 1719), by J. Parkinson (Organic Remains. II, pl. XIII, f. 59 1808), and in *I. tuberculatus* by E. F. Honnorat («Note sur le *Pentacrinus tuberculatus.*» *Bull. Soc. Sci. lit. Basses Alpes*, pl. fig. 11; 1883). The two stems of *Isocrinus jurensis* with six lobes, figured by P. de Loriol, (Paleont. Française, Crinoides Jurassiques, pl. CXLIV, ff. 7 & 10; 1886) are not regularly hexamerous. Bateson, in his «Materials for the study of Variation» (p. 436; 1894) was unable to add any instances. Lissajous (*Bull. Soc. Hist. Nat. Macon*, Nos. 16, 17, p. 22; 1900) has described a stem-fragment of *Balanocrinus subteres* with six petals on the joint-face, but four cirri at the node. Honnorat (loc. cit., ff. 12, 13, 14) has figured one irregularly heptagonal, and two almost regular hexagonal columnars of *I. tuberculatus;* he mentions five hexagonal, of which he describes three as «géométriquement régulière». These last are the only cases of regular hexamerism in *Isocrinus* that have come to my knowledge, with the exception of the specimen of *I. Hercuniae* here figured.

The following are measurements of hypozygals in millimetres:

Diameter	3·2	4·1	4·5	5·4	5·7	6·0	6·6
Height	0·9	0·8	0·9	1·1	1·1	1·1	1·1
Diam. = 100, height = .	28	19	20	20	19	18	16

Taking the diameter as 100, the average height of an internodal, as deduced from 20 specimens, is 21. But if the adults, with diameter from 4·5 to 6·7 mm., be considered apart, then the average height, as deduced from 9 specimens, is 16·7. The average height of adult nodals, as deduced from 8 specimens of corresponding size, is 24·75, while the average height of 5 hypozygals of corresponding size is 18·6. It follows from the above measurements that relative height decreases with age at about the same rate in normal columnals and hypozygals, but less rapidly in the case of nodals. The relative height of the nodals is nearly 3/2 that of normal columnals; thus, taking an individual specimen, a nodal of height 1·3 mm. is adjacent to internodals of 0·94 mm average height. The hypozygals are a little higher than ordinary internodals of corresponding diameter.

The variation in height of adjacent normal internodals is slight; occasionally they may differ as much as 0·9 and 1·1 mm. Regular alternation cannot as a rule be detected, possibly because the fragments are not long enough, all being under 11 ossicles in length, except one, whereas the complete intersyzygia must have been much longer. The one exception consists of 15 columnals, beginning with an epizygal, but not reaching the hypozygal; counting from, but not including, the epizygal, every fourth internodal is slightly higher than the rest, while the first and third appear in each case to be very slightly lower than the second; thus there are four orders of columnals, the nodals being order I. The evidence for the length of the internodes is indirect, since no complete intersyzygium has been found. But the fact that fragments of 15, 11, and fewer columnals occur with no more than one nodal, shows that they must have had a length exceeding those numbers. This is confirmed by the relative rarity of epizygals and hypozygals; thus the bulk of the material from the most prolific locality consists of:

Fragments of all sizes without epizygals or hypozygals	302
» » » » with epizygals	42
» » » » with hypozygals	32
Total . .	376

Side-faces smooth, usually slightly convex, but almost straight in some stellate and pentagonal forms. There is no tendency for a median ridge to be developed. Nodals not swollen.

Suture-lines depressed, with a distinct cavity in the re-entrant angles; but the sutural edges bounding this are not quite regular, there being frequently a marginal swelling which tends to divide the cavity into two. Crenelation of the suture-line is most clearly seen in concavi-stellate forms, but even here it is somewhat obscured by the depression and by the partial confluence of the crenellae; in other forms it is seen only at the interradial angles, and then but obscurely.

Joint-faces. — Normal (figs. 103, 111): Lumen minute, subcircular. Central area raised, usually smooth, narrow, but merging insensibly into the radial ridge-groups. Petal-floors sharply depressed, smooth, or rarely granulate and that chiefly at their outer ends. usually lozenge-shaped, the short diameter of the lozenge bisecting the floor equally only in pentagonal ossicles, but approaching the lumen as the excav ation of the re-entrant angles increases; the lozenge may lose its lateral angles and so become lanceolate. The radial ridge-groups vary considerably in structure, but the variations form a connected series, though it may be doubted which end of the series is the more primitive. Thus, in some joint-faces they consist of adradial crenellae, similar to, and continous with, the peripheral crenellae, inosculating at an angle with those of the adjacent petal, i. e. arranged herring-bone fashion; in rare cases a few may meet gable-fashion; towards the lumen these crenellae become smaller and less regular, till they appear only as confused anastomosing granules; there has been found no specimen in which definite crenellae continue up to the central area. In the next stage a greater number of the crenellae have passed into the irregular granular condition, so that at last the whole ridge-group may be merely a raised granular area, with the granules increasing in size centrifugally. In what appears to be the next stage, the granules are arranged in two rows, continuing the lines of such crenellae as persist at the distal end.. Finally the granules of each now fuse, so that the ridge-group now consists of two ridges that radiate from the central area and may either diverge or lie parallel. As variants on these main stages, the radial ridges are sometimes broken up into quite regular granules or small crenellae, which usually lie at right angles to the radius, and may meet across it, as in *Balanocrinus;* or they may even point towards the lumen, and, meeting thus, form reversed gables. The peripheral crenellae follow regularly on the normal adradial crenellae, the longest of all the crenellae being, as usual, those where the two series meet, their length varying inversely as the excavation of the re-entrant angle. The crenellae of each petal diverge from the interradius, sometimes fan-wise, but sometimes almost at the same angle so that those of each side are parallel. The number of peripheral crenellae in a petal varies from 6 or 7 in a columnal of 2·5 mm. diameter to 14 or 15 in columnars of 5 mm. to 7 mm. diameter. The number also increases, at the expense of the adradial crenellae, with the excavation of the re-entrant angles. The crenellae widen at their outer ends and usually run together, especially at the bottom of the intervening grooves, thus reducing the crenelation of the suture-line.

A rebate edge may completely surround the joint-face, but broadens at the radii, forming radial triangles. The base of these is often excavate, and the apica angle always obtuse. The basal margin may be raised, especially on the radius, into a ridge or lip; and this may extend inwards as a radial crest. In one specimen the contrary variation has been observed, the radial region of the triangle being still more depressed.

The following measurements in millimetres are from an internodal of average shape, size, and development:

Diameter	5·3
Length of interradius	2·8
Length of radius	2·2
Distance from lumen to end of petal-floor	2·2

Length of shortest crenella	0·4
Length of longest crenella	1·7
Width of a crenella	0·5
Distance from lumen to apex of radial triangle . . .	0·7
Distance from apex to base of radial triangle . . .	0·15

Syzygial faces (figs. 108—110, 112): The number of syzygial columnals, as already explained, is relatively few; and of these again only a small proportion expose the syzygial faces. The stems appear to have broken with equal or even greater ease at the joint above the nodal, while there are not a few cases of syzygial ossicles united to each other but separate from the rest. These facts suggest that the union was firm and not brittle. It is impossible to say whether there was any difference in structure between the syzygials still united and those that have come apart.

Epizygals (figs. 109, 110, 112). In most cases the surface is worn, and merely suggests a normal joint-face with all its features less accentuated: one can trace the peripheral crenellae, the radial ridge-groups, and the depressed petal-floors; the radial triangle, however, appears to be absent, or else present only as the end of a single radial ridge, formed by the concrescence of the ridge-group. Better preserved specimens show a more complicated structure. There are traces of the original crenellae at the outer ends of the petals; but they appear to be overlaid, or in part replaced, by another system of crenellae very much finer. These fine crenellae surround the petal-floor, always at right angles to its border, and pass without break into the adradial series, which form two rows of crenellae alternating and inosculating along the radius, to which they are at right angles. Centrally they merge into the raised area. Five of these crenellae and five intervening grooves go to half a millimetre, i. e. the width of one crenella is 0·05 mm., or one-tenth the width of a normal crenella. In these specimens the radial triangle is very faintly indicated, and the rebate rim does not pass round the petals. The crenellae therefore come right to the edge of the suture, but their extreme fineness renders them imperceptible on the side-face of an unbroken syzygy.

Hypozygals (fig. 108) in their simplest form show a raised margin to the rosette, outside which are the radial triangles and the rebate margin The petal-floors are gently swollen. The extent to which the crenellae are atrophied varies much: sometimes they are merely obscured; sometimes the radial ridge-groups are represented by slight ridges; sometimes the only traces of the original crenellae and granules are bands of colour lighter than the petal-floors, owing to the larger proportion of organic substance in these latter.* Well-preserved specimens show a new series of fine crenellae similar to those of the epizygal and similarly arranged: they bear no relation to the degree of atrophy of the larger crenellae, but both may be present in the same region.

The cirrus-facets (figs. 114—116) occupy the whole height of the nodal, while indications of their presence may sometimes be detected on the supranodal and hypozygal; they are directed very slightly upwards. Each facet is transversely elliptical, with a well-defined rim, which however always tends to be deformed from

* See BATHER «Crinoidea of Gotland. I.» *Svensk. Vet.-Akad. Handl* XXV, No. 2, p. 151; 1893.

a true ellipse in the following manner: the lower margin is straight and parallel to the suture-line; the upper margin retains the broad elliptical curve, while the suture-line above it rises and, as it were, cuts into the supranodal, so that the rim of the facet here assumes the position which between other columnars is occupied by the cavity; the side margins form short curves, the chords of which approach as they pass downwards. A strong fulcrum runs across the facet well above the centre, forming the chord to the upper curve of the rim; it is swollen at its ends, which are quite distinct from the rim, and widens slightly around the lumen; it often has a slight median groove. The facet, measured from outside its rim, occupies nearly three-quarters the width of a columnar side. Its surface is curved to accord with the re-entrant angle of the columnar. Since this angle is always more marked in the epizygal than in the hypozygal, a portion of the latter forms a wall for the facet, and may occasionally take the place of the lower straight portion of the rim. The extent to which the facet is sunk into the columnar varies; usually the rim rises straight up from the general level, but sometimes it is surrounded by a groove.

The following measurements of the cirrus-facet in millimetres are taken from normal adult specimens:

Diameter of nodal	6·4	6·0	5·7	5·4	4·5
Width of side	3·9	3·9	3·5	3·3	2·7
Width of facet	2·8	2·8	2·6	2·4	2·0
Height of facet	1·5	1·3	1·3	1·2	1·1

Cirrals: In only one specimen *(f)*, and on only one side of it, is a fragment of a cirrus preserved (fig. 115). This consists of cirrals 1 and 2. Their transverse diameter is 1·3 mm.; their vertical diameter, 1·0 mm.; the length of the fragment is 0 5 mm. The distal joint-face of cirral 2 is worn; its outline is more regularly elliptical than that of the columnar cirrus-facet; a faint fulcrum lies in its upper half, and towards it slope the upper and lower portions of the surface; a slight depression near the margin of the lower half produces the appearance of a rim. The upward bend of the cirrals is very slight, and probably not more than can be accounted for by the upward slope of the columnar cirrus-facet.

Relations of the Species. — Differing, as it does, in almost every feature possible from the other *Isocrini* of the Veszprém district, *I. Hercuniae* could not be confused with any of them. Among other Triassic species it comes nearest to *I. propinquus* (MÜNSTER,) and in fact some of the specimens were submitted to me with that name already attached. Possibly the published descriptions and figures of *I. propinquus* would justify such a reference; but study of the type-specimens and of the abundant material of that species preserved in the museums of Munich, Vienna, and London enables me to state the following characters in which it differs from the present species.

The relative height of the internodals in *I. propinquus* is about two-thirds that in *I. Hercuniae*, the average of 19 specimens being 14·26, as opposed to 21 in the latter, and the extremes noted being 19 and 12 as opposed to 32 and 13, the diameter being taken as 100 in each case. The crenelation of the suture-line is more distinct at the interradial angles in *I. propinquus.* MÜNSTER and LAUBE state distinctly that the internodals of *I. propinquus* are all equal in height; were this so, it would be another point of difference; but the fact is that the alternation in size is of precisely the same character as in *I. Hercuniae.* The apical angle of the radial triangle is always obtuse in *I. Hercuniae,* but in *I. propinquus* it is acute, as a rule, if not always. The secondary series of fine crenellae, so characteristic of the syzygial faces in *I. Hercuniae,* has not been observed in a single specimen of *I. propinquus.* The cirrus-facet of *I. propinquus,* in so far as it departs from an elliptical outline, approaches lenticular (Pl. V, fig. 119), and the upper rim extends into the hypozygal, which often takes part in it.

Some of the forms referred by various authors to *I. propinquus,* in my opinion wrongly, may resemble *I. Hercuniae* in a feature here and there; but there are many other points in which they differ.

Thus, in the collection of the Geologische Reichsanstalt at Vienna, among LAUBE's originals of *I. propinquus* is a small stem-fragment (Pl. V, fig. 118) which, to judge from its size and general outline, might be the original of LAUBE's plate VIIIa, fig. 17b; the fact that its details are quite unlike the drawing is no proof to the contrary. It consists of 5 columnals, of which the fourth from the top is an epizygal. The points in which it differs from the normal *I. propinquus* and approaches *I. Hercuniae* are these. The diameter being 3 mm. and the average height of the internodals 0·7 mm., the resulting relative height of the latter, 23 : 100, agrees with that of similarly sized columns of *I. Hercuniae.* The total number of crenellae in a petal, both adradial and peripheral, is only 7 or 8, fewer than in either *I. propinquus* or *I. Hercuniae.* The radial triangle, though distinct, is very small The cirrus-facet does not extend over any part of the supranodal; its outline is not lenticular but four-sided, being flattened below, less so above, and with the ends curved, while the chords of the curves trend upwards and inwards, not downwards and inwards as in *I. Hercuniae.* One cirral is preserved; its distal joint-face has an inner rim below, as well as the outer one, cutting off a crescentic area. In the position of the cirrus-facet, and of its fulcrum, and in the height of the nodal, 1 mm., this specimen agrees with either *I. propinquus* or *I. Hercuniae.* Clearly the specimen is not a normal *I. propinquus;* but on the evidence of this single fragment, it would not be safe to say that *I. Hercuniae* occurred at St. Cassian.

The single stem-fragment from the Pachycardien Tuffe of the Seiser Alp in the Tyrol referred to *I. propinquus* by F. BROILI* has been examined by me in the Palaeontological Museum, Munich, and found to present the following features. The suture-line is crenelate in the re-entrant angles. The height of the internodals is to the diameter as 10 to 100, that of internodals of *I. propinquus* of equal size being 13 or 14 to 100. The joint-face drawn is that of a hypozygal; it shows no radial groove, but a very long radial triangle separates the adradial crenellae. The specimen therefore, while differing from the true *I. propinquus,* does not approach *I. Hercuniae.*

The specimens (Pl. V, figs. 120—122) from the Cardita-Oolite of Rammelsbach near Seehaus, figured by S. von WÖHRMANN** as *Pentacrinus propinquus,* and other specimens from the Raibl Beds of Naunspitze near Kufstein, also preserved under

* *Palaeontographica,* L, p. 151, pl. XVII, f. 8; Jan. 1904 (Author's copy received June, 1903).

** *Jahrb. d. k. k. geol. Reichsanst.* Wien, XXXIX, p. 191, pl. V, f. 9; 1889.

that name in the Palaeontological Museum, Munich, differ from both *I. propinquus* and *I. Hercuniae* in many respects. It is enough to mention that they have no rim or radial triangle, but a suture-line therefore crenelate all round; side-faces concave or concavo-convex with raised suture-lines; a regularly elliptical cirrus-facet, not occupying the whole height of the nodal.

Isocrinus Hercuniae, then, appears to be a mutation of *I. propinquus*, probably originating in Raiblian times from immigrants of that species into the Bakony area.

These two species *I. propinquus* and *I. Hercuniae* are of interest because, though true *Isocrini*, they possess in the well-marked radial triangle a feature that is conspicuous in *Pentacrinus* (s. str.), while the arrangement of the radial ridge-groups, as already noted, occasionally approaches that found in *Balanocrinus*.

Isocrinus sp.

Material. — A fragment of reddish rock from Vászoly, Zalamegye, Ágasmagas, contains numerous white fragments of a Pentacrinine stem. It is labelled «Muschelkalk».

Description of the Specimens. — No joint-faces and no side-faces are exposed, but there are a few transverse sections, varying from sub-pentagonal to slightly quinquelobate.

Diameters: 2·3 mm., 2·1 mm., 1·6 mm. Height of last specimen, 1·0 mm.

Diameter of lumen about 0·2 mm.

Relations of the Specimens. — Of the species described in this memoir, *Isocrinus sceptrum* is that which these fragments most resemble.

General note on the Pentacrinine columnals from Bakony It is somewhat remarkable that, among the thousands of specimens collected, there should be scarcely a trace of anything but stem-fragments, the only exceptions being the single patina and the single brachial, next to be described. Even when the fragments have been still in the matrix, as in the specimen last described, I have been unable to detect anything but columnals and occasional cirrals. From the Quarry near Cutting I on the Veszprém-Jutas Railway there are several fragments of *Isocrinus Hercuniae* preserved in matrix. These show that the rock is largely composed of the remains of this crinoid; but that they are not in the position in which the animal grew. The stems are all in short pieces, lying in different directions. The extraordinary number of stem-fragments of *Isocrinus sceptrum* suggests that they also were found in disorder close together, forming a large pro portion of the rock.

The probable explanation of all these occurrences is that the death of the animals was followed by the partial decay and separation of the skeletons, and that the fragments were then sorted out according to relative size by the action of currents. Possibly a lenticle or pocket almost entirely filled with brachials of one or other of these species may be found some day; but, since those fragments are less conspicuous, such a bed is likely to be overlooked. We now proceed to the only two such fragments that have been found.

Isocrinus? sp.

(Plate V. figs. 123—126)

Material. — A patina from Cserhát (Leitnerhof). Cassian age.

Description of Specimen. — This consists of five radials and five basals. In a side-view of the patina (fig. 123) the basals reach upwards to more than half its height. They are rounded and swollen so as to project very slightly beyond the radials; the most prominent part of each basal is between its two upper angles. Below they curve inwards and upwards, forming a deeply hollowed base (fig. 124), which was filled with matrix. After the extraction of the matrix there were visible no traces of infrabasals, but the interbasal sutures were seen to stretch right up and, apparently though not quite certainly, as far as the radial angles of a small pentagonal opening. At a slight distance from this opening the basals bend a little more sharply, thus producing a faint circular depression, perhaps the stem-facet, but with no trace of striae.

The radials are swollen, but not so rounded as the basals. The most prominent part, or umbo, of each radial, lies between the two lower angles, or a little below that level; from here the plate slopes inwards to the margin of the facet, forming a rather flatter subtriangular surface, the edges of which run from the umbo to the shoulders of the radial, which is rather narrower above than below. The facet then bends abruptly inwards. The combined facets and muscle-plates of the radials form an approximately horizontal surface at the top of the patina, with but a small central concavity. The details of this surface (fig. 125) are not very clearly seen, since the specimen has been somewhat rolled or weathered. The fulcral ridge faces outwards, with a nearly straight outer or dorsal margin; it contains an oval axial canal with the long diameter parallel to the ridge. The dorsal ligament-fossa is a smooth depression. From the middle of the fulcral ridge, at a little distance from the axial canal, a slight groove extends to the central cavity, deepening as it goes; it is bordered on each side by a very slight ridge, parallel with it. Outside these ridges, and next the fulcral ridge, on each side, is a triangular depression, presumably for the interarticular ligament. On this assumption the muscles were attached to the more adcentral regions of the facet — the muscle-plates; but no fossae or striae are distinguishable.

Greatest diameter of patina, at basal and radial umbones . .	4·0	mm.
Greatest height of patina	2·7	»
Height of basals	1·9 to 2·1	»
Width of basals	2·0 to 2·1	»
Height of radials	circa 1·4	»
Width of radials below	circa 2·1	»
Width of radials above	circa 2·0	»
Width of basal excavation	1·0	»

Relations of the Specimen. — The preceding account agrees fully with the reference of the patina to *Isocrinus*. The absence of infrabasals, the general shape, and the details of the upper surface preclude a reference to the Encrinidae. The absence of infrabasals shows that the specimen does not belong to *Dadocrinus*, *Holocrinus*, or *Pentacrinus* (s. str.). Of Triassic Pentacrinidae there remain only *Isocrinus* and *Balanocrinus;* and since the former is common at Cserhát, while the latter has not yet been recorded from this district, the obvious course is to refer the patina to *Isocrinus.*

To which, if any, of the species of *Isocrinus* recorded from the neighbourhood it may belong, it is impossible to say certainly. At Cserhát occur *I. candelabrum*, *I. scipio*, and *I. Hercuniae* (?). Of these the first and last are too large except in quite young specimens, while the representatives of *I. Hercuniae* at Cserhát are few and doubtful. *I. scipio* on the other hand is by far the commonest species at Cserhát, and its diameter agrees better with the diameter of the stem-facet, than does that of any other species except *I. sceptrum.* There is also a sort of general resemblance between the smooth swollen nodals of *I. scipio* and the plates of this patina. Such an argument may not carry conviction; but it is a fact that the outward appearance and ornament of theca, arms, and stem of any species are harmonious. For all these reasons I incline to regard this patina as belonging to *I. scipio;* but, as already admitted, absolute proof is impossible with the material in hand.

To whichever species this patina may belong, it is of considerable interest, not merely as the only patina of any crinoid whatsoever from the Trias of Bakony, but, so far as I can recall, the only patina of *Isocrinus* known from the Trias. It is indeed true that both Münster and Laube have described and figured a fossil which they regard as the patina of a Pentacrinine, the former referring a specimen with doubt to his *Pentacrinus subcrenatus*, the latter being apparently uncertain whether to call his specimen *P. subcrenatus* or *P. laevigatus.* Both these species, however, belong to *Balanocrinus*, as already stated. But, apart from this, examination of the original specimens and of a number of similar specimens at Munich and Vienna and in the British Museum (registered E 5299) has convinced me that the fossil is not a patina at all and that it forms no part of a Pentacrinid.

The undoubted patina now before us is therefore the only evidence available as to the stage of evolution of the cup of *Isocrinus* in Triassic times. It is noteworthy that the species had already attained the pseudo-monocyclic (or crypto-dicyclic) stage. That the patina does not belong to a true monocyclic crinoid is proved by the radial position of the angles of the pentagonal opening in the base. The excavation of the base is remarkable and by no means characteristic of *Isocrinus;* it reminds one of the base of *Encrinus.* The height of the basals and their appearance as a closed circlet in side view are characters only found occasionally in *Isocrinus* and then always regarded as primitive. The slight contraction of the patina towards its upper margin is characteristic of *Holocrinus*, but not of *Isocrinus.* The flatness of the upper surface and the horizontal extension of the muscle-plates remind one of the Encrinidae rather than the Pentacrininae.

In short, the patina, though with but little doubt belonging to a genus of Pentacrininae, still presents features reminiscent of the earlier Pentacrinidae and their probable ancestors the Encrinidae.

Isocrinus? sp.

(Plate V. fig. 127).

Material. — A brachial from Cserhát (Leitnerhof). Cassian age.

Description of Specimen. — The outline is approximately circular, but not bilaterally symmetrical.

The ventral groove is narrow, V-shaped, and confluent with the axial canal, which is traceable as a slight enlargement of the apex of the groove.

The two articular surfaces are dissimilar. One extends almost to the periphery, and is rather rough, perhaps owing to weathering. The groove slopes downwards to the left, so that the right-hand half is the larger. The surface swells up around the apex of the groove in two confluent knobs which form a rudimentary fulcrum. The left-hand shoulder passes almost imperceptibly into the side of the ossicle and presents no depressions or ridges. On the left side the wall of the groove is about at right angles to the joint-face. The right-hand edge of the groove is bevelled, the slope becoming wider towards the upper angle of the brachial. Next the edge of this slope is a slight triangular depression, also widening towards the upper angles of the brachial. The right shoulder is slightly bevelled. From this bevel an obscure rim bounds the dorsal or lower edge of the joint-face.

The other articular surface is smaller; the sides of the brachial curve inwards, so that the boundary of the face lies about half-way between the periphery and the ventral groove. In accordance with the asymmetrical slope of the groove, the larger half both of brachial and of joint-face is on the left-hand side. The face is excavate, sloping from the boundary downwards to the groove in a gentle curve. The upper right-hand edge of the groove has a straight bevel similar to that seen on the other face, but oblong instead of triangular. Outside this bevel is a flat bevelled surface sloping in the other direction and almost continuous with the general curve of the side of the brachial. This outer bevel may be a facet for a pinnule. Immediately around the apex of the groove the surface is slightly depressed, perhaps to receive elevations like those seen on the other face.

Total height along dorso-ventral axis	2·6	mm.
Greatest width	2·7	»
Greatest thickness	1·1	»
Depth of ventral groove	1·2	»

Relations of the Specimen. — The joint-face first described appears to be that of a normal brachial. The triangular depression on the right of the ventral groove was probably the muscle-fossa, while the slight depression within the dorsal rim was for the reception of the dorsal ligament. The interarticular ligament was probably diffused over the surface around the fulcral elevation. The other excavate joint-face, though less clearly marked, cannot have been syzygial if the outer bevel represents a pinnule-facet; the inner bevel, on the right of the ventral groove, was perhaps for the attachment of the ventral muscle on that side.

The surfaces therefore present no features which forbid the reference to *Isocrinus*, although they are distinctly primitive in the slight differentiation of ridges and fossae, and, above all, in the confluence of the ventral groove with the axial canal

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ECHINOIDEA.

The Echinoid remains from the Balaton district consist of radioles, of isolated plates or larger fragments of test, and of portions of the jaw-apparatus. As in the case of similar material from St. Cassian, the different structures do not occur in such intimate association that one can be said to belong to the other. It is therefore necessary to treat them quite separately, leaving it for future discoverers to associate the radioles and jaw-fragments with their respective tests. The only case in which another course might have been more convenient is that of *Anaulocidaris testudo*, for here there is reason to believe that certain interambulacrals were the bearers of certain radioles. The evidence, however, is not direct but circumstantial and presumptive, so that the conclusion was come to very gradually and may after all be wrong.

Since, so far as these Triassic remains are concerned, it is rarely, if ever, possible to be sure of the genus to which a radiole or a jaw-element belongs, a better idea of the systematic relations of the fauna will be obtained if the fragments of test are taken first. Unfortunately even these are so incomplete, ambulacrals and interambulacrals being rarely found in conjunction, that their ascription to established genera is frequently subject to much doubt. If I have ventured to name more of these small and obscure remains than scientific caution warrants, it has been less with the intention of professing an illusory perfection, than in the hope of attracting to them the attention of better qualified critics. It would not have been altogether blameworthy to pass by the greater number of these fossils as «indeterminable fragments», and so to save the excessive delay that has resulted from my attempt at an exhaustive study. But if material of this kind is to be described at all, the description must be minute. Only thus can the work have any value for either stratigrapher or zoologist.

The fragments of test.

Terminology. — The terminology at present applied to the test, as also to the other skeletal elements, of the Echinoidea, has been gradually evolved from the days of Aristotle through the writings of many authors, of whom the following are hereinafter referred to:

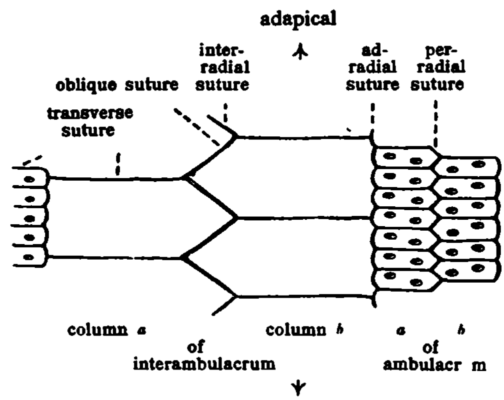
J. T. Klein, Naturalis dispositio Echinodermatum. Gedani; 1734.

C. Des Moulins, Études sur les Échinides. Actes Soc. Linn. Bordeaux, VII, pp. 167—245, 315—432; 1835, and IX, pp. 45—364; 1837. Separately issued, pp. 1—520.

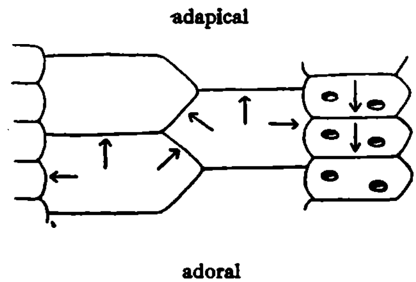
A. GRAS, Descr. des oursins foss. du Dept. de l'Isère. Bull. Soc. stat. Isére, IV, p. 289 and p. 444; 1848.
T. WRIGHT, Monograph on the Brit. foss. Echinodermata of the Oolitic formations. Part I. London, Palaontogr. Soc.; 1857.
E. DESOR, Synopsis des Échinides fossiles, pp. X—XIII; 1858.
A. AGASSIZ, Revision of the Echini, Part IV. Illustr. Catal. Mus. Comp. Zool. Harvard; 1874.
S. LOVÉN, Études sur les Échinoïdées. Svensk. Vet.-Akad. Handl. (n. s.) XI, No. 7; 1875.
P. M. DUNCAN, Revision of the ... Echinoidea. J. Linn. Soc., Zool., XXIII; 1889. See pp. 295—304.

The terminology of the last-mentioned author is followed so far as possible; but, since every increase in precision of description demands the revision of accepted terms or the addition of new ones, it may save ambiguity if attention be here drawn to a few of those frequently used in this memoir.

The Test of a Regular Echinoid in the normal position has an upper apical pole and a lower oral pole. With reference to these poles, the regions of the test or of its



Text-fig. 6. Geneneral orientation of Echinoid ambulacra and interambulacra.



Text-fig. 7. The normal direction of imbrication in Echinoid ambulacrals and interambulacrals is shown by the arrows.

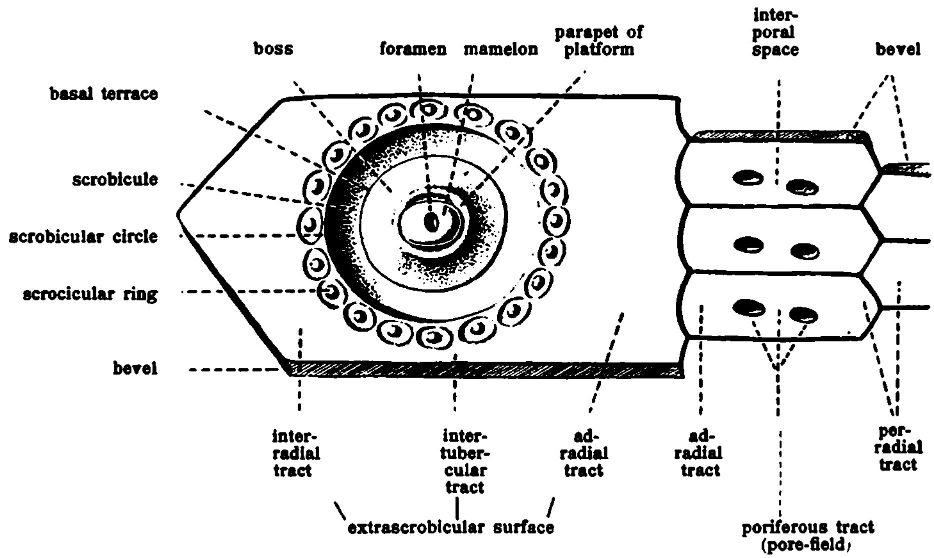
components are adapical or adoral. There is no need for such terms as dorsal, ventral, abactinal, actinal, which generally breed confusion.

We deal here only with the Corona, i. e. the test minus the apical system and plates of the peristomial and periproctal membranes. The corona is composed of ambulacra (strictly these should be called ambulacral areas) and interambulacra. These meet along the «ambulacro-interradial vertical sutures» (DUNCAN) here termed adradial sutures. (Text-fig. 6.)

Each Interambulacrum consists of plates, called interambulacrals, which, in the genera hereinafter discussed, except those of the Tiarechinidae, are arranged in two vertical columns, meeting in a zigzag suture, the interradial suture; and each Ambulacrum consists of two columns of ambulacrals meeting in the perradial suture. In questions of orientation the numbering of LOVEN (1875, pp. 13, 14, 20 et sqq.) is used whenever possible. In accordance therewith, in any isolated ambulacrum or interambulacrum, as viewed from the exterior with the adapical end uppermost, the column on the observer's left hand is designated *a*, that on his right hand *b*. The plates in each column are numbered 1, 2, 3, etc., starting from the adoral end.

A fully developed Interambulacral has 5 sutural margins. In such a plate of a *b* column the margins, taken in a solar or clock-wise direction, are adradial, adoral, orad-interradial, apicad-interradial, and adapical. The same terms may be applied to an ambulacral, with the substitution of «-perradial» for «-interradial». In both cases the adoral and adapical margins meet in the transverse sutures, and the interradial or perradial margins in oblique sutures.

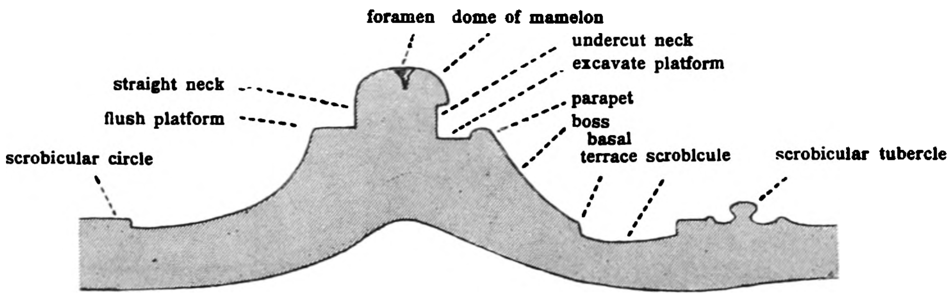
In nearly all the Triassic Echinoidea each interambulacral bears only one primary tubercle, which may therefore be more briefly referred to as the main tubercle. The smooth space surrounding it, and defined in life by the attachment of the external radiolar muscles, is the scrobicule. The surface of an interambulacrum (as also of a single interambulacral) is therefore either intrascrobicular or extrascrobicular. In any single plate the term scrobicule is frequently extended to the whole intra-scrobicular surface: thus, the radius of a scrobicule being a straight line from the centre of the tubercle to the outer edge of the scrobicule, the diameter is twice that radius; and a scrobicule is described as large or small according as its diameter is greater or less in proportion to the size of the plate. On the other hand, the width of a scrobicule is measured from the outer edge of the boss to the outer edge of the scrobicule; and a scrobicule is described as broad or narrow according as its width is greater or less in proportion to its diameter as above defined. Thus a large scrobicule may be narrow and a small scrobicule may be broad. Neither diameter nor width includes the scrobicular ring (*vide infra*). The extrascrobicular surface may be divided into the following tracts: a meridionally continuous median interradial tract (the «miliary zone» of Desor); a meridionally continuous adradial tract on each side of the interambulacrum; a discontinuous meridional series of intertubercular tracts in each column, aborted when the scrobicules are contiguous or confluent. (Text-fig. 8.)



Text-fig. 8. Terminology of Echinoid interambulacrals and ambulacrals.

An Ambulacrum may be divided into five continuous meridional tracts: two outer adradial; two poriferous; and one median perradial. A. GRAS, DESOR, DUNCAN, and others have called this last tract «the interporiferous zone or area», a term which is liable to confusion with the interporal space between the two pores of a pair. A less cumbrous term for the poriferous tract is pore-field. To use the term «zone» for these meridional tracts, as was originally proposed by A. GRAS «pour éviter toute confusion» (1848, p. 298), seems a curious distortion of its original meaning. C. DESMOULINS (1835, p. 135) called the perradial tract «la portion interambulacraire», since in his terminology the interradial areas were «anambulacraire». (Text-fig. 8.)

A main Tubercle with its immediate surroundings consists of the following parts, beginning at the centre (Text-figs. 8, 9.). The mamelon, which may be perforate by a circular or elliptic foramen or imperforate, with its dome hemispherical or depressed hemispherical, with circumference circular or slightly distorted from a circle so as to be meridionally elongate or transversely elongate, i. e. parallel to the equator. The elongation of the mamelon is often at right angles to that of its foramen. The neck of the mamelon, which comes immediately below the dome may be straight, i. e. with sides parallel to the axis of the tubercle, or slightly undercut. The neck is



Text-fig. 9. Section of a main tubercle. The right and left halves are represented as being different.

borne by the boss, and usually rests on a definite platform cut at right angles to the axis of the tubercle. This platform may be flush, or excavate so as to appear surrounded by a parapet. The parapet or, in its absence, the edge of the platform, may be crenelate or plain (briefly expressed by «tubercle crenelate or non-crenelate»). The outer wall of the platform or of the parapet may be vertical for a short distance, or the boss may at once begin to slope away with a straight, concave, or convex slope, which may be continuous until it dies away in the scrobicule, or may be interrupted by a ledge, defined in life by the attachment of the internal radiolar muscles, and forming a kind of subsidiary platform — the basal terrace (A. TORNQUIST, N. Jahrb. f. Mineral., 1896, II, p. 35). The scrobicule is usually sunk below the level of the extrascrobicular surface, and thus forms a moat or fossa around the boss. The outer edge or vallum of this moat is the scrobicular circle. This is usually surmounted by a definite series of scrobicular tubercles constituting a scrobicular ring. Even when the scrobicule is flush with the extrascrobicular surface, and when consequently the scrobicular circle is not in evidence, the limits of the scrobicule are generally marked by the scrobicular ring. If this also is undeveloped, then the scrobicule is distinguished from the extrascrobicular surface by the general ornament of tubercles or granules on the latter. This discrimination between the scrobicular circle and the ring of scrobicular tubercles may conflict with the usage of some eminent authorities, but appears in accord with the language of the first proposer of the term, A. GRAS («Ce scrobicule est parfois bordé à sa circonférence d'un cercle plus ou moins saillant et serré de tubercules, cercle que nous appellerons *scrobiculaire*». 1848, p. 301). When a clear intertubercular tract intervenes between the scrobicular rings of a meridian, then the scrobicules are termed distinct and separate. When the scrobicular rings are complete, each in itself, but separated by no such space, the scrobicules are distinct but adjacent. When the scrobicular circles remain complete, but when the rings meet so that there is only one line of tubercles between the scrobicules, then the scrobicules are contiguous. When the scrobicules are so close that both their rings and circles are incomplete and one scrobicule merges in another, then the scrobicules are confluent.

The physiological significance of the undercut neck, the platform, the parapet, and the crenelation is not at once apparent. The internal sheath connecting the boss with the radiole was formerly supposed to consist of elastic ligament-fibres, but J. von UEXKÜLL (1899, Zeitschr. f. Biol. XXXIX, p. 73) has shown that it is muscular and serves to hold the radiole rigidly erect; it passes from the basal terrace, over the crenellae of the boss, and is attached to the base of the radiole below the occasionally crenelate collar of the latter. Therefore neither the crenellae of the boss nor the grooves between them serve as points of attachment for the internal muscle-fibres. They may, however, hold the fibres in a straight line, and thus check torsion of the radiole. The space beneath the internal muscle-sheath, formed by the undercutting of the neck and excavation of the platform may be due partly to economy of material, while it may also facilitate the movement of the acetabulum over the mamelon, may allow room for the swelling of the muscles when the radiole is drawn over, and finally may provide a soft cushion to save from injury by accidental pressure or blows the nerve-ring which lies at exactly this level in the epidermis covering the union of tubercle and radiole.

The remaining Ornament of the interambulacra consists of tubercles or granules, of which the former are distinguished by being mamelonate. These tubercles are secondary, tertiary, and so on according to their size. The principal scrobicular tubercles are almost invariably larger than any others, and are therefore secondary. Secondary tubercles are frequently scrobiculate; they may also be perforate and crenelate. Granules are devoid of mamelon, perforation, crenellae, and scrobicule. The term «miliaries» («miliary tubercles» or «miliary granules») is often used, but there seems considerable uncertainty in its application. DUNCAN (1889, p. 298) says miliaries are «very small tubercles incomplete in their division into parts», while «granules are more or less nodular projections of the test»: this is far from clear. WRIGHT (1857, p. 14) distinguishes granules from tubercles in the same way as is done here, and then opposes them to miliaries in the following manner: «granules are . . . scattered more or less regularly, and distributed over different parts of the plates of the test», while «*miliary granulation* is formed by a number of small granules closely set together» in the perradial tracts or the interradial tracts, and these tracts he calls the *miliary zones*. Since, however, ordinary granules may, as stated by WRIGHT, occur in the perradial tract of *Cidaris*, and since a close-set irregular granulation is often found in the adradial tracts of the interambulacra, situation fails as a criterion. A. AGASSIZ (1874, p. 636) distinguishes «miliary tubercles» from «granules», but defines neither; it is, however, granules and not miliary tubercles which, according to him, occur in the miliary zones. To escape the confusion exemplified by these quotations, it is time that we returned to the simple conception of C. DESMOULINS (1835, p. 15). For him all eminences bearing skeletal processes (radioles, pedicellariae, &c.) were «tubercules», and of these he distinguished two kinds, namely the «tubercules miliaires» strewn over the extra-scrobicular surface, without perforation, mamelon, crenellae, or scrobicule, and the «tubercules papillaires» which always have a mamelon borne on a boss. He also recognised in certain species «tubercules granuliformes» (1835, p. 39) and «tubercules verruciformes» (1835, pp. 42, 45, 47, 50, 53), both of which he regarded as modified papillaries. DESMOULINS may have adopted the term «miliaire», which means *like millet seed*, from the «Cidaris miliaris . . . cujus Eminentiae *Milii* granulis aequales aut minores» of KLEIN (1734), or from the «miliary eruption» of certain fevers, but not from the «miliary tubercle» of tuberculosis. It would be well to return to the usage of DESMOULINS, to speak of all eminences that bear skeletal appendages as tubercles, distinguishing as papillaries those with a mamelon, and as miliaries those without one. The term papillaries has, however, dropped so entirely out of use, being superseded by tubercles (*sensu restr.*), that it cannot now be revived. The following scheme seems therefore the simplest and most practical:

Minor eminences of the test are

A) Appendage-bearing

1. With distinct mamelon — T u b e r c l e s,
   further divided into primary, secondary, &c. according to their relative size in each species.
2. Without mamelon — M i l i a r i e s,
   which may be close-set or sparsely scattered, regular or irregular.

B) Bearing no appendages — G r a n u l e s,
   which may vary in size, shape, and distribution, and are frequently to be regarded as products of the «Epistroma» (LOVÉN).

The sutures between plates or areas, or the margins of the plates, are said to be v e r t i c a l when at right angles to the tangential plane which they touch; if at an angle to this plane they are said to be b e v e l l e d; if the angle formed by the sutural surface and the outer surface of the plate is less than a right angle, then the bevel faces inward and the margin is described as bevelled on its inner surface; if the said angle is greater than a right angle, the bevel faces outward. A succession of bevels in a meridional or transverse series produces i m b r i c a t i o n. In a meridional series, if the adapical margins are bevelled on their inner surfaces, so that each plate overlaps its adapical neighbour, then the imbrication is a d a p i c a l, and this is stated by DUNCAN to be the general rule for interambulacra.* If the adoral margins are bevelled on their inner surfaces, then the imbrication is a d o r a l, and this is stated by DUNCAN to be the general rule for ambulacra.** In the corona of Echinoids with two columns of interambulacrals, the only imbrication in a transverse direction is that along the adradial suture; and this, if it occurs, is generally, if not always, such that the interambulacrum overlaps the ambulacrum. In Echinoids with more than two columns of interambulacrals, such observations as have been made show a tendency for the admedian plates to overlap the outer plates. Consequently the general rule may be provisionally stated that transverse imbrication in Echinoid interambulacrals is a d r a d i a l. In such thick-plated forms as *Melonites*, *Oligoporus*, and *Palaechinus*, the bevel of the adradial margin of the interambulacrum faces outward; but the bevel is so slight that JACKSON & JAGGAR (1896, Bull. Geol. Soc. Amer., VII, p. 154) are scarcely justified in calling

* Exceptions are *Pholidocidaris* and *Lepidocentrus*; see R. T. JACKSON, 1896, Bull. Geol. Soc. Amer., VII, pp. 211, 244.

** *Astropyga*, at least, is an exception, *fide* A. AGASSIZ, 1881, Challenger Rep. Echinoidea, p. 71

it imbrication; it is due to the arcuate transverse section of the ambulacrum, and their own explanation of the slightly inclined edges of the plates in general is equally applicable to this particular case. The direction of imbrication has often been stated too vaguely, and often, as later observations have proved, quite incorrectly; hence the preceding elementary exposition may not be out of place. (Text-fig. 7.)

Methods of measurement. — All measurements are in millimetres, and have been taken with sliding callipers provided with a vernier scale reading to tenths of a millimetre. For the sake of comparison between the diagnoses it is preferable to express in the form of ratios such measurements as are given therein, taking some one measurement as a constant. Unfortunately the fragmentary nature of the specimens has not left any single measurement which can conveniently be used in this way. Only in a few cases have relative measurements been calculated from a constant chosen for each set of cases.

The height of a complete test is the distance measured vertically from the vertex to the base-plane, that is the flat horizontal surface on which the denuded test assumes stable equilibrium in its natural posture. Owing to the almost universal absence of the apical system from even the best specimens of Triassic Echinoids, one is reduced to giving the height of the corona; but since it is probable that in the forms under examination the apical system added little or nothing to the height, this makes little practical difference, and previous authors have no doubt meant the corona when they have spoken of the test.

The diameter of a scrobicule is the diameter of the scrobicular circle, and does not include the ring.

The height of a plate is its greatest meridional diameter. The width of a plate is its greatest transverse diameter, parallel to the transverse sutures.

Classification. — Fortunately no discussion of the broader divisions is necessary, since, with the exception of the doubtful *Tiarechinus* fragment, all the specimens appear to fall into either the Cidaridae or the primitive Ectobranchiata frequently grouped in a Suborder Diademina, of which the division into Families is as yet far from settled. It will therefore be most convenient to take the genera in the usually accepted systematic order, and to introduce such remarks on their relationships as may be advisable under the discussion of each genus. The genera are *Tiarechinus ?*[1], *Triadocidaris, Anaulocidaris, Miocidaris, Plegiocidaris, Eodiadema, Mesodiadema,* and *Diademopsis.*

[1] A note on the recently alleged affinity of *Tiarechinus* to the Arbaciidae will be given at the close of the memoir; see the Index.

ORDER: CIDAROIDA.

FAMILY: TIARECHINIDAE.

For diagnosis, vide infra, p. 67.

Tiarechinus.

1881. *Haueria* G. C. LAUBE. MS., cit. NEUMAYR, op. cit. infra, p. 170.
1881. *Tiarechinus* M. NEUMAYR, Sitzber. k. Akad. Wiss. Wien, LXXXIV, Abth. I, p. 169.
See also:
1883. A. AGASSIZ, „Blake Echini", Mem. Mus. Harvard, X, No. 1, p. 22.
1883. S. LOVEN, «Pourtalesia», Svensk Vet.-Akad. Handl. XIX, Mem. No. 7, pp. 11, 64, pl. XIII.
1889. P. M. DUNCAN, «Revision of Echinoidea», J. Linn. Soc., Zool. XXIII, p. 19.
1889. M. NEUMAYR, «Die Stämme des Thierreiches», p. 365.
1896. R. T. JACKSON, «Studies of Palaeechinoidea», Bull. Geol. Soc. Amer., VII, p. 243, & table annexed.
1897. J. W. GREGORY, Proc. Zool. Soc. London, 1896, p. 1000.
1900. J. W. GREGORY, «Treatise on Zoology», ed. LANKESTER, III, Echinoderma, p. 305.
1900. J. LAMBERT, Bull. Soc. Sci. Yonne, LIII, p. 44, & Tableau B.
1903. K. A. v. ZITTEL, «Grundzüge der Palaeontologie» 2e. Aufl., p. 206.
1904. Y. DELAGE & E. HÉROUARD, »Traité de Zool. concrète», III, p. 219.

Before giving the diagnosis, it is necessary to discuss the systematic position of the genus.

NEUMAYR (1881) rejected the name *Haueria* «da schon eine *Hauera* UNGER und eine *Hauerina* ORB. existirt». It does not appear that *Haueria* has ever yet been used, and now presumably, thanks to NEUMAYR's action, it never can be adopted for any animal.

The genotype and only known species is *Tiarechinus princeps* NEUMAYR (1881, ex Laube MS.), which has been admirably described by NEUMAYR (loc. cit.) and by LOVEN (1883). DUNCAN (1889) founded for the genus the Order Plesiocidaroida, which was retained by Prof. JACKSON (1896) and redefined by Dr. GREGORY in his interesting paper on *Lysechinus* (1897) as well as in 1900. Though the establishment of the Order may have been justified by the sudden jump from 1 to 3 interambulacrals in *Tiarechinus*, it is hard to see why GREGORY retained it, realising as he did that, as regards the interambulacral plates, his genus *Lysechinus*, if correctly interpreted by him, «bridges the gap between *Tiarechinus* and the Palaeozoic Echinids», and that the preponderance of the apical system is not an ancestral character. NEUMAYR (1881, p. 174) provisionally placed *Tiarechinus* in the Archaeocidaridae; but in 1889, when he fully discussed the question, he merely regarded the genus as better referred to the Palaechinoids than to the Euechinoids, a conclusion carried into effect by Professors DELAGE and HÉROUARD (March, 1904). Except for NEUMAYR's reference to the Archaeocidaridae, unfortunately overlooked by GREGORY, no one has yet claimed any Family of Palaeozoic Echinoidea for the ancestors of *Tiarechinus*. Whether Dr GREGORY's interpretation of the fossil on which he founded his *Lysechinus* be correct or no (and I ought to say that I have utterly failed to verify it after repeated efforts), at all events it is theoretically plausible, and it suggests to me that the most probable ancestors were the Lepidocentridae. The flexibility of the test in that Family is so strongly contrasted with the rigidity of *Tiarechinus*, that the suggestion may seem absurd; but, as may be gathered from JACKSON's excellent paper (1896), there is no essential difference as regards more important morphological features. On this hypothesis the Tiarechinidae would form a Family of GREGORY's Order Cidaroida, which is thus defined (1900, p. 301): «Echinoidea

Regularia Endobranchiata, in which the peristome is central; the periproct is central on the aboral surface of the body, and is surrounded by the apical system of plates. The ambulacra each consist of two vertical series of simple narrow plates, some of which may be demi-plates. The interambulacral plates are unituberculate, bearing large spines. There is a dental apparatus». [See footnote, p. 65!]

Dr. GREGORY placed the genera *Tiarechinus* and *Lysechinus* in distinct Families, laying stress on the greater number of interambulacrals in the latter genus, and especially on the limitation of its ambulacra to the oral surface. Accepting Dr. GREGORY's account of those interambulacrals, which he himself admits to be doubtful, it will be observed that the arrangement in *Tiarechinus* can, as he says, «easily have been produced from it by the resorption of the second zone of interambulacral plates and increase in height of those of the third zone», or, it may be added, by the vertical fusion of those in the third and fourth zones. *Tiarechinus princeps* may therefore in its youthful stages have had interambulacrals like those thought by GREGORY to exist in *Lysechinus*. Quite apart then from the extreme uncertainty attaching to it, the character does not appear of more than generic importance. But by describing the ambulacra of *Tiarechinus* as «desmactinic» (1900, p. 305) and those of *Lysechinus* as «lysactinic» (1897, p. 1004), Dr. GREGORY postulates a fundamental difference between the two genera. This difference simply does not exist. «Desmactinic» means that the ambulacra are continuous from peristome to apical system, as in Echinoidea generally; while «lysactinic» means, not only that they are limited to the oral surface, but that they are separated from the apical system by intervening plates as in Asteroidea. But in *Lysechinus*, as GREGORY's own diagram shows, the ambulacra bear to the apical system precisely the same relation that they bear in *Tiarechinus*. The oculars of *Lysechinus* are represented as far larger and as passing down between the interambulacrals, but not as being separated from the ambulacra. Therefore the ambulacra are not lysactinic. They are not even «limited to grooves on the oral surface», for, as shown in GREGORY's figures 1*b* and 2*b*, their aboral portions are clearly visible in side view. LAMBERT (1900), then, did well in reducing the Families Tiarechinidae and Lysechinidae to the rank of Sub-Families, but VON ZITTEL (1903) and DELAGE and HÉROUARD (1904) did better in retaining only the Family Tiarechinidae. The statement contained in the Family-diagnosis of the latter authors that «une des plaques interambulacraires empiète sur la membrane péristomienne», would, if correct, ally the Family to the Archaeocidaridae rather than to the Lepidocentridae. But it is due to some misapprehension, since the fact that the interambulacrum begins with a single plate, which does not invade the peristomial membrane, is one of the most important characters of the Family. The following is a

Revised Diagnosis of the Family *Tiarechinidae.*

Cidaroida with plates closely united into a small rigid test, of which nearly half is occupied by the apical system. Ambulacra short, with plates all primaries and pore-pairs uniserial. Interambulacra begin with a single peristomial plate, and increase gradually or immediately to three plates in a horizontal row.

Revised diagnosis of *Tiarechinus.*

A Tiarechinid in which the single peristomial plate of each interambulacrum is succeeded by a horizontal row of three vertically elongate plates, the outer ones abutting on the ambulacra, the oculars, and the genitals.

Genotype: *T. princeps* NEUMAYR.

Revised diagnosis of *Lysechinus* (based on the observations of GREGORY). A Tiarechinid in which the single peristomial plate of each interambulacrum is succeeded by a horizontal row of two plates abutting on the ambulacra and the oculars and this by a horizontal row of three plates, the outer ones abutting only on the oculars, and this finally by a horizontal row of three plates. the outer ones abutting on the oculars and the genitals.

Genotype: *L. incongruens* GREGORY.

Tiarechinus ? sp.

(Plate VI, fig. 128.)

Material. — A fragment, adherent to matrix, from the Cassian beds of Cserhát (Leitnerhof).

Description of the Specimen. — Height, 8.7 mm. Width, 6.5 mm.

Along one margin are 12 rounded projections, each about 0.8 mm. wide, and rising slightly above the general surface. At one end, the lower in fig. 128, this margin seems to bend sharply round on itself, and there is a slight elevation at the angle. The remaining surface of the fossil is covered with small pustules (? tubercles), irregular in size and arrangement; and between them is a very fine granulation (? miliaries).

Relations of the Specimen. — It is with great hesitation that I refer this exceedingly obscure fragment to *Tiarechinus,* and I do so largely because there is no other form which it suggests either to me or to others who have kindly examined it. The absence of any appearance of definite sutures, even after prolonged treatment with glycerine and alcohol, is no evidence to the contrary; indeed a more vivid imagination might interpret as sutures the markings or cracks which are to be detected with some difficulty. The general ornament is similar to that on the interambulacrals and plates of the apical system in *Tiarechinus.* The interpretation provisionally suggested is that the fragment is the greater part of an interambulacrum, of which the adambulacral border is preserved on one side (the right in fig. 128). The projections on this border are supposed to be more prominent tubercles alternating with the ambulacral plates. It is possible that the sharp bend at the end of this border represents the adapical end of the ambulacrum, in which case the oral end has been placed uppermost in fig. 128. The curvature of the fragment is not unlike that shown in LOVEN's figures 153, 154; but if the specimen be *Tiarechinus,* it represents a form at least twice the size of any Tiarechinid hitherto described.

FAMILY: CIDARIDAE.

Equals Section I of Cidaridae DUNCAN (J. Linn. Soc., Zool., XXIII, p. 26; 1889), as restricted by J. W. GREGORY («Treatise on Zoology», ed. LANKESTER, III, p. 302; 1900.)

Triadocidaris.

1887. *Triadocidaris* L. DOEDERLEIN: «Japanischen Seeigel», p. 39.

1900. *Triadocidaris* DOED., J. LAMBERT: Bull. Soc. Sci. l'Yonne, LIII, p. 44. In addition to MÜNSTER 1841, and LAUBE, 1865, see also

1887. L. DOEDERLEIN: N. Jahrb. f. Mineral. 1887, II, pp. 1—4, pl. i.

1896. A. TORNQUIST: N. Jahrb. f. Mineral. 1896, II, p. 42.

Diagnosis. — A Cidarid with the adradial margin of the interambulacrum obliquely bevelled on the inner surface and denticulate, thus flexibly imbricating over the ambulacrum. Main interambulacral tubercles perforate, non-crenelate, with large scrobicules, either distinct or confluent. Podial pores not yoked.

This differs from Prof. DOEDERLEIN'S diagnosis mainly in the omission of the statement that the scrobicules are not sunk; they may be either flush or sunk.

DOEDERLEIN referred to his genus four species in the following order: *Cidaris venusta* MÜNST., *C. subsimilis* MÜNST., and *C. Liagora* MÜNST., all with distinct scrobicules, and *C. Suessi* LAUBE with confluent scrobicules. He did not however fix on any one of these as genotype, and since LAMBERT (1900) has removed *C. venusta* to *Microcidaris* on account of its vertical and rigid adradial sutures, it is advisable definitely to adopt as genolectotype the next species, *C. subsimilis*. LAMBERT (1900) has added to the genus *Cidaris subnobilis* MÜNST., which DOEDERLEIN (1887, p. 40) had doubtfully referred to *Miocidaris*. None of these species is found in Bakony, but there are the remains of *Triadocidaris persimilis* n. sp. and of one or two indeterminable species from the Cserhát group, and of *T. praeternobilis* n. sp. from the Jeruzsálemhegy group. The names given are intended to imply that the two species emphasise the features of the St. Cassian *T. subsimilis* and *T. subnobilis* respectively. The Jeruzsálemhegy group also furnishes a species, *T. immunita*, which shows resemblances to both *Anaulocidaris* and *Mesodiadema*.

The most interesting character in *Triadocidaris*, as in some other early genera, is the flexibility of the adradial suture. This feature, to which Prof. DOEDERLEIN first drew attention (N. Jahrb. Mineral. 1887, II, pp. 1—4, pl. i), has been held by LAMBERT (1900, p. 53) to warrant the separation of such Cidarid genera as a Sub-Family Streptocidarinae opposed to the remaining genera, which all have rigid adradial sutures and constitute the Sub-Family Stereocidarinae. LAMBERT'S Streptocidarinae would thus include the *Triadocidaris* and *Miocidaris* of DOEDERLEIN, and *Eotiaris* LAMBERT 1900. This last however it is difficult if not impossible to separate from *Miocidaris*, as will be explained later. Thus the Streptocidarinae come to consist of only two genera, which differ solely in the bosses of the main tubercles, those of *Triadocidaris* being plain and those of *Miocidaris* crenelate. Study of the Bakony Echinoids and re-examination of other Permian and Triassic species, while confirming the broad fact of flexibility in the adradial sutures of these genera and indeed extending it to species that appear to be primitive Ectobranchiata (e. g. *Mesodiadema)*, nevertheless indicates that the transition from a flexible to a rigid union was — as one would have expected — extremely gradual, and that in a single individual the union might be flexible in one region of the adradial suture, but rigid in another region. Consequently, as LAMBERT'S transference of *Triadocidaris venusta* to *Microcidaris* has already exemplified, this feature alone does not always enable one to distinguish even genera, and still less is it a suitable criterion for the distinction of two Sub-families. At most one can speak only of a Streptocidarine Grade or stage of evolution. But even this is in some respects misleading, since such a stage is by no means confined to Cidaridae. The flexibility of the adradial suture is but part of a general flexibility common to many of the older Echinoidea and manifested also in the sutures between the interambulacrals themselves. *Triadocidaris* and other Triassic Echinoids are passing from this Streptosomatous stage to the Stereosomatous condition found in the majority of later forms. The nature of the change will be more readily comprehended after perusal of the following descriptions, which also correct an error in the generally received account (see p. 73.)

Triadocidaris persimilis[1] n. sp.

(Plate VI. figs. 129—134.)

Diagnosis. — A *Triadocidaris* with height of test circa 0.7 diameter; with 4 interambulacrals in a column, of which the ambital ones are higher than wide, while the space between their scrobicules is greater than the diameter of the scrobicules; scrobicule circular, sunk; platform of boss higher than tops of scrobicular tubercles, distinctly wider than mamelon, flat; scrobicular ring of 14—15 secondary tubercles, with intercalated miliaries often radiately disposed; extrascrobicular surface filled with secondary tubercles equal to or slightly smaller than scrobicular tubercles, with interspersed miliaries. Ambulacra sinuous, with 18 ambulacrals to each ambital interambulacral, an inner alternating series of tubercles, with miliaries intercalated on the median line at the adoral end; outer pores transversely elongate and merging in a groove.

Material.— From Cserhát (Leitnerhof) come 16 fragments, of which 3 (viz., *a, b, h*) contain ambulacrals as well as interambulacrals, while the rest are composed only of interambulacrals or fragments of the same. Seven out of the 16 have been selected as the basis of the following description, and are lettered *a—g*. Of these *a*, which consists of an almost complete ambulacrum and interambulacrum, is taken as holotype (figs. 131 - 134). The remaining 9 are denoted by *h—q*.

From bed *e* 4 at cutting VI on the Veszprém-Jutas Railroad comes a fragmentary plate, lettered *r* and provisionally referred to this species.

Three fragmentary interambulacrals, lettered *s, t, u*, were collected by Prof. LACZKÓ in Giricses-Domb, Lower stratified Limestone.

Seven imperfectly preserved interambulacral fragments, also from Cserhát, are doubtfully referred here.

All these are of Cassian age.

Description of the Specimens. — Specimen *a* (figs. 131, 133.) gives the height of the test as 10.2 mm.; and an ambital diameter, estimated by completing the pentagon, of 14.7 mm. The height is therefore circa 0.7 of diameter. Comparison with the rest of the material indicates that *a* was of normal dimensions, though a larger size was sometimes attained. Thus the largest interambulacral plate in *a* is 5.8 mm. high and 5.1 mm. wide. Specimen *f* is a plate 7.6 mm. high; specimen *j* a plate with a diameter of at least 7.1 mm.; and specimen *s* a fragment of a plate more than 9 mm. high. Assuming the measurements of the test to be proportional to those of its several plates, we arrive at the following minimal dimensions in millimetres for the complete tests of specimens —

	f	*j*	*s*
height	13·3	14·2	15·8+
diameter	19·2	20·9	22·8+

Thus the exceptionally large specimen *s* would just about attain the diameter of the specimen of *T. subsimilis* figured by LAUBE (1865, pl. VIII b, f. 4), viz 23 mm. The height of that specimen is 14 mm. and the height of MÜNSTER's holotype was

[1] *Very like*, to express the resemblance to *T. subsimilis*.

not less than 18 mm ; so that the diameter of the latter was probably about 30 mm. It appears then that *T. persimilis* is generally of smaller dimensions than *T. subsimilis*; but since smaller specimens of the latter species are known (e. g. Brit. Mus. 36479 and E8547, with diameters 11.25 mm. and 9.3 mm.) much stress should not be laid on that. If, however, LAUBE's measurements are to be accepted rather than his words «kuglig-rund, wenig zusammengedrückt», *T. subsimilis* is more depressed than *T. persimilis*, its height being only 0.6 of the diameter, while in the smaller specimens just mentioned the ratio is respectively 0.56 and circa 0.54.

The number of interambulacrals in a column is 4, the fourth being either minute with the main tubercle almost vanishing — if at the adoral end, or rather larger but with tubercle as yet undeveloped — if at the adapical end. These numbers agree with those given by LAUBE for *T. subsimilis*, and the arrangement of the plates agrees with that observed in the holotype of that species, but LAUBE's figure 4 of pl VIII b, if at all correct, strongly suggests that LAUBE did not reckon the minute plates at the adoral end, while the holotype is also suggestive of more than 4 plates to a column. At any rate in the small specimen Brit. Mus. 36479 one of the two columns in each interambulacrum has 5 plates, while the other has 4; and both columns appear to have had 5 plates in E8547.

All the interambulacrals, except the small adoral ones, are higher than wide, whereas in *T. subsimilis* the height is about equal to the width. The space between any two scrobicules in meridional series is greater than the diameter of the largest adjacent scrobicule; in *T. subsimilis* the converse is the case. The space between the adjacent scrobicules of the right and left columns, measured across the interradial tract, is only half that width. The scrobicules are sharply sunk, though those of *Triadocidaris* are described as flush in DOEDERLEIN's diagnosis. In *T subsimilis*, however, they may be slightly sunk. The bosses, which occasionally show very faint traces of a basal terrace, rise with fairly straight or slightly concave slope to a platform rather higher than the tops of the scrobicular tubercles. This platform is distinctly wider than the mamelon, has no parapet, and, though normally plain, may show isolated and faint traces of crenelation. The mamelon is circular, slightly undercut; with the perforation of fair size and, especially in adoral tubercles, elongate vertically. In *T. subsimilis* the platform is not so high, but the mamelon is relatively wider and far more prominent. The following measurements will make the preceding points more clear:

	T. persimilis		*T subsimilis*	
	a	*b*	holotype	36479
Height of largest interambulacral	5·8	4·2	7·5	2·8
Width » » »	5·1	4·1	7·5	3·1
Diameter of scrobicule	3·0	2·3	5·2	2·15
» » boss, circa	2·0	—	3·2	1·3
» » mamelon	1·0	0·82	2·4	0·75
Intertubercular tract measured vertically at the ambitus	3·6	2·7 ?	3·5	0·8
Ditto, nearer oral pole	2·3	2·3	2·7	0·8
Greatest width of Interambulacrum	7·3	5·6	12·8	5·1
» » » Ambulacrum	2·0	2·0	3·5	1·6
Height of test	10·2	—	18·+?	6·3
Diameter of test	14·7?	12·0?	30·0?	11·25

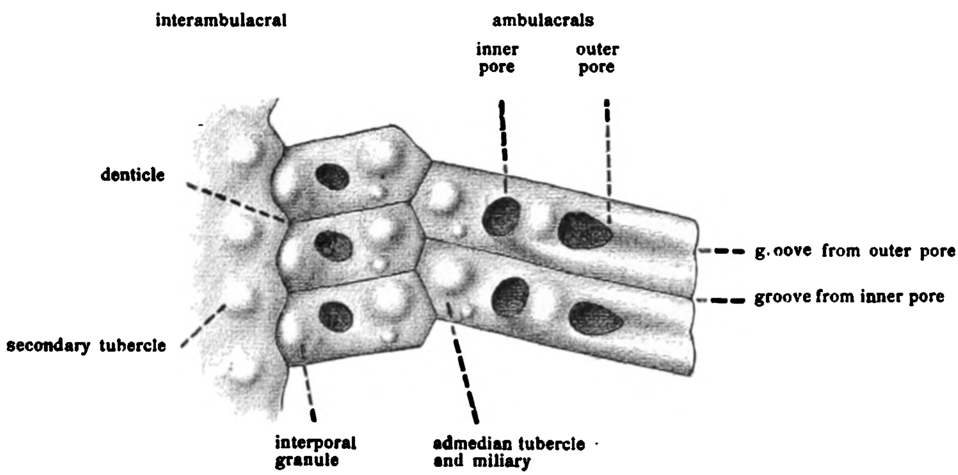
From these measurements it appears that, although the smaller and presumably younger specimens of the two species are, as might be expected, not quite so divergent as are the larger ones, still even they present the differences mentioned above.

A scrobicular ring is formed by 14 or 15 secondary tubercles, between which are intercalated miliaries or tertiary tubercles, frequently two arranged radially in each of the spaces, just as represented by LAUBE (1865, pl. IX, f. 1) for *T. subsimilis.* The extrascrobicular surface is filled with secondary tubercles as large as, or sometimes very little smaller than, those of the ring, while among them tertiary tubercles are irregularly scattered. In *a* this ornament is very clearly marked, the secondary tubercles being mamelonate, but apparently not perforate. In the largest intertubercular tract, 3.6 mm. across, about 6 or 7 secondaries lie in a line, including the scrobicular tubercles; in a smaller tract, 2.3 mm. across, there are about 4 in a line; in each case miliaries intervene. In *c* and *f* the ornament is less distinct, the tubercles being either ill developed, or worn down, thus producing an apparent tendency to anastomose. In *g*, which is possibly not this species but a fragment of *C. Liagora*, the scrobicular tubercles are plainly, though slightly, larger than the extra-scrobicular secondaries, while the latter together with the intermingled tertiaries are widely spaced and rather regularly arranged, and a line of tertiaries borders the adradial margin. In *g*, 3 well-defined secondaries with their surrounding miliaries occupy 2.3 mm., while 4 secondaries occupy 2.6 mm. Setting *g* aside, *T. subsimilis* is seen to differ from *T. persimilis*, first in the scrobicular ring being more prominent than the extra-scrobicular secondaries, as is clearly shown in LAUBE's pl. IX f. 1*b*, secondly in the absolute paucity and relative sparseness of the extra-scrobicular secondaries, as correctly represented in MÜNSTER's and LAUBE's figures of the holotype. Specimen *g* though in these respects approaching *T. subsimilis*, is plainly differentiated by the distinctness and regularity of its ornament.

The ambulacra (figs. 132, 134) are sinuous and at the ambitus their width is from 0.274 to 0.357 that of the interambulacrum; these ratios are very close to those presented by *T. subsimilis*. The number of ambulacrals to an ambital interambulacral is 18, the number in *T. subsimilis* being 15—18. Their transverse sutures slope slightly in an orad direction towards the radius. The perradial tract bears two rows of tubercles, intermediate in size between the secondary and tertiary tubercles of the interambulacrum, and these tubercles, being one to each ambulacral plate, form a regularly alternating series, except at the adoral end, where a few miliaries are intercalated between the two rows. There are no other tubercles on the ambulacrum, but a very minute miliary can with difficulty be detected on the adoral outer side of several main tubercles. MÜNSTER mentions a series of tubercles outside the pore-fields in *T. subsimilis*, but they appear to be really on the edge of the interambulacrals, so there is no difference between the two species in this respect. The inner pores are circular, or very slightly extended transversely in connection with a groove which leads from each pore along the orad margin of the ambulacral, on the suture line, to the outer edge of the ambulacrum. The outer pores are markedly elongate transversely and each is connected with a wider groove running along the middle of the ambulacral, parallel with the sutural groove, to the outer edge of the ambulacrum. The sides of this groove continue as a ridge round the inner margin of the outer pore and so separate it from the inner pore, and this portion of the ridge may be slightly raised into a granule. In *T. subsimilis* holotype this granule is more pronounced, and it may have been this that led Münster to assert the presence of an outer row of tubercles; in that specimen it is continued into a definite ridge on the adapical side of each inner pore, which ridge does not continue the ridge forming the adapical boundary of the outer pore, but is more adoral in position; thus the inner pore is, or appears to be, nearer the oral pole than is its fellow outer pore. In the small British Museum specimen of *T. subsimilis* (36479) the elevations between the two pores of a pair are relatively still more conspicuous, but the outer pores are here too much covered by the interambulacra for the relations of the ridges to be made out. In the still smaller test E8547, neither the admedian nor the interporal series of tubercles are well developed, but the position of the pores is as in the holotype. In all specimens the outer pores appear less elongate than in *T. persimilis.*

In both *T. persimilis* and *T. subsimilis* the ornament of the ambulacra, and in the latter species the mutual relations of the two pores of a pair, enable one, in the absence of other evidence, to orient any fragment containing ambulacrals. It is, indeed, the rule in Echinoidea that the inner pore of a pair is more adoral. Thus one learns that Münster's pl. III f. 2 is not merely reversed by the mirror, but has the adoral end uppermost, while Laube's drawing of the same specimen (pl. IX, f 1 *c*) has the adoral end downwards and is not reversed.

The Union between Ambulacra and Interambulacra. — In the ambital and adapical regions the surface of the ambulacrum outside the interporal elevation slopes inwards (i. e. towards the interior of the test) so as to pass beneath the interambulacrum, as is usual in the genus. Thus the extreme edge of the ambulacrum is only seen when the interambulacrals are removed, and is then found to be slightly scolloped, the notches between the scollops coinciding with the grooves from the pores, one on the suture between successive ambulacrals and one in the middle of each ambulacral. In *a* the edge of the interambulacrum is concavely scolloped, each scollop corresponding to an ambulacral; and the projections between the scollops lie in the grooves between adjacent ambulacrals. A similar arrangement



Text fig. 10. Diagram to show relations of ambulacrals to interambulacrals in *Triadocidaris persimilis.* The lefthand column of ambulacrals is partly pushed under the interambulacral. × 36 diam.

is seen in *T. subsimilis* (E8547). The projections between the scollops may or may not correspond with secondary interambulacral tubercles. The projections, as shown by specimen *c* (figs. 124, 130), pass over the edges of the interambulacral plates, which are bevelled on the inner surface, and form thereon a series of denticles, which gradually die away on the inner surface of the interambulacrals. Where the denticles die out is a slight depression, followed by a slight ridge parallel with the adradial margin. The spaces between the denticles are twice as wide as the denticles. Comparison of all the available specimens shows a change in the suture as it passes from the adapical to the adoral region (fig. 129). In the adapical and ambital regions the bevel on the inner surface of the interambulacral margin slopes gently so as to form a sharp edge, and on this bevelled surface lie the denticles, the spaces between them corresponding, as above described, with the concave scollops of the extreme edge. Towards the adoral end the edge gradually thickens, and a portion of the bevelled surface comes to lie at a much steeper slope, until, at the extreme adoral end, the suture is at right angles to the outer surface and is considerably thickened so as to form a relatively broad ridged surface inosculating with the ambulacrals. Thus the regions of the suture from apical to oral present a series similar to that regarded by Prof. Doederlein (1887 N. Jahrb. f. Mineral.) as the historical succession, and represented in his figures 5 (*T. subsimilis*), 6 (*T. liagora*), 8 (*Rhabdocidaris anglo-suevica*), 10 (*Cidaris Thouarsi*). This fact is not necessarily opposed to Prof. Doederlein's hypothesis, but it shows the danger of basing general statements on isolated fragments, and suggests the exercise of great care in using the bevel of the suture as a means of distinguishing *Triadocidaris* from *Microcidaris*. One result of this structure is to give flexibility to the adapical region and rigidity to the adoral, this rigidity being, no doubt, correlated with the development of a peristomial framework. The inner surface of the interambulacrum, as seen for instance in *c* (fig. 130) and *d*, does in fact present a thickening along the border of the peristome, rising into an elevation at each adradial angle. Confirmation of this suggested rigidity is presented by the partly crushed small specimen of *T. subsimilis* (E8547). Here the plates of the adoral region of the test retain their normal position, while in the upper half the interambulacra are markedly thrust over the ambulacra as far as to the inner pores.

So far as the material in the British Museum allows one to judge, all the species of *Triadocidaris* present a structure like that just described. It may be thought that the admirable and suggestive papers by Prof. Doederlein render this minute account unnecessary. It must therefore be pointed out that the present account differs from that of my eminent predecessor, not merely in the description of structural variation in different regions of the suture, but in the essential details as to the articulation of the bevelled surfaces. While the appearances presented by those surfaces when separated suggested to Prof. Doederlein that each denticle of the interambulacrum fitted into a groove or depression in the middle of the corresponding ambulacral, and though such an interpretation affords a needed and a plausible explanation of the grooves in question, still none of the united specimens before me, whatever its degree of overthrust, confirms that inference; on the contrary, the denticles, or the points of the scollops in which they end, invariably rest in the other series of grooves, those, namely, between the ambulacrals. Thus at a certain degree of overthrust the concavity of the scollop corresponds with the outer margin of the outer pore, leaving a free exit for the podium. Should the overthrust proceed further, as one can see that it occasionally did, then the pore would be gradually closed, allowing time for the withdrawal of the podium; and eventually the overthrust would be checked by two structures — the meridional ridge on the inner surface of the interambulacrum, and the elevation or granule between the inner and outer pores. If this interpretation be admitted, what, it may be asked, is the meaning of the groove or depression in the middle of each ambulacral? Perhaps it was a fossa for the attachment of a muscle or ligament; perhaps, together with the groove from the other pore, it was a furrow for fibrils of the peripheral nervous system.[1]

I should hesitate to oppose this interpretation to that of Prof. DOEDERLEIN, were it not that his account is inconsistent with his own hypothesis of the evolution of the modern type of suture. On that hypothesis «die Rippen, die auf die Randfläche beschränkt bleiben, verursachen die zickzackförmige Knickung». In the zigzag suture of a recent Cidarid, the projections of the interambulacrum alternate with the ambulacrals, and it is obviously the meaning of Prof. DOEDERLEIN that these projections are homologous with the ridges or denticles. This homology may in fact be regarded as proved by the change observed in the different regions of a single suture in *T. persimilis*. But if so, the denticles must alternate with the ambulacrals instead of coinciding with them. And the observation of united specimens, as opposed to Prof. DOEDERLEIN's inference from isolated fragments, shows that they do alternate.

A further argument against Prof. DOEDERLEIN's view is presented by various species of other genera (e. g. *Echinocrinus* = *Archaeocidaris*, as observed by A. TORNQUIST, N. Jahrb. f. Mineral. 1896, II, p. 42), in which, although the interambulacral margin is denticulate, there are no grooves on the ambulacrals.

In *T. persimilis* the other margins of the interambulacrals are not exposed as a rule, but the plates are broken across at other levels, a fact which shows that the union was close and rigid. Only in specimens *s* and *t* can any part of a transverse sutural surface be detected; it is vertical or very slightly bevelled, with a faint median depression.

Relations of the Species. — In *T. venusta* the scrobicular ring consists of only 7—8 small secondaries, and the ambulacra, according to MÜNSTER, are quite straight. *T. Liagora*, which has similar ornament, has a larger number of interambulacrals in a column, with the result that the scrobicules are contiguous, with scrobicular tubercles reduced in size, or are even confluent. In *T. Suessi* a further increase in the number of interambulacrals results in more elliptical and more confluent scrobicules. In *T. subnobilis* also the scrobicules are confluent and have no definite ring of tubercles. The remaining species *T. subsimilis* is more closely allied to *T. persimilis* than are any of the preceding, and the two might perhaps be considered as local races. As has been shown in detail, *T. persimilis* is smaller, more depressed, with perhaps fewer interambulacrals in column, and, consequently, with interambulacrals relatively higher, and much larger intertubercular tracts; the mamelon of the main tubercles is narrower and less prominent, the secondary tubercles are more numerous and those of the scrobicular ring less pronounced; the ambulacra differ in minute details, perhaps of merely individual significance.

Taking the major differences, we may place the species of *Triadocidaris* hitherto described, excluding *T. venusta*, which LAMBERT refers to *Microcidaris*, in

[1] See PROUHO «Recherches sur le *Dorocidaris*», Arch Zool. Exper. (2) V, p. 245, pl. XIV, fig. 2, *sn*.

a series according to the height and number of the interambulacrals, thus: *T. persimilis, T. subsimilis, T. Liagora, T. Suessi,* and *T. subnobilis.* Such an order also shows an increase in the definiteness of the scrobicular ring from *T. persimilis* to *T. Liagora,* but this progress is then interfered with by the increasing confluence of the scrobicules. Whether such an arrangement represents an evolutionary series is another question, on which some light is thrown by the species next to be described — *T. praeternobilis.*

Triadocidaris? sp. indet. α.

Material. — A primary interambulacral tubercle, with all the extra-scrobicular and much of the intra-scrobicular portion of the plate missing; from Bed *e* 4 at Cutting VI on the Veszprém—Jutas Railroad; of Cassian age.

Description of the Specimen. — Mamelon relatively rather large, perforate, depressed hemispherical, very slightly undercut, diameter 1.7 mm., on a platform of 2.3 mm. diameter, with slight parapet, not much raised above scrobicule floor; diameter of scrobicule, circa 5.0 mm.; a scrobicular ring probably present, but only about two small tubercles remain at one corner of the specimen. Thickness of plate at scrobcule, 0.7 mm.; to top of platform, 1.3 mm.; to top of mamelon, 2.25 mm.

Triadocidaris praeternobilis[1] n. sp.

(Plate VI. figs. 135—138.)

Diagnosis. — A *Triadocidaris* in which the ambital interambulacrals have scrobicules sunk, elliptical, confluent, and with no scrobicular ring. Extra-scrobicular interradial tract with secondary and tertiary tubercles alternating in meridional sequence, one of each on each plate; these are clearly mamelonate, perforate, scrobiculate, and are surrounded by quaternaries and miliaries dense and irregular. About 7 ambulacrals to each ambital interambulacral.

Material. — *a* (fig 138) Fragment of an interambulacrum, comprising the interradial tract with two main tubercles on one side, their scrobicules incomplete, and the margins of three scrobicules on the other side; from Jeruzsálemhegy. This is the holotype. *b* (figs. 135—137) Fragment of an interambulacrum, consisting of two plates from which the interradial tract has been broken away; Railroad Veszprém—Jutas, Cutting I. Both are of Raiblian age.

These two specimens supplement one another; indeed the only parts they have in common are the actual tubercles; but I have scarcely any doubt as to their specific identity. In the following description the portions referring to the adradial border are based on specimen *b* alone.

Description of the Specimens. — The plates appear to be not far removed from the ambitus, and may therefore be regarded as fairly representative.

The plates are low, with scrobicules sharply sunk, vertically compressed, and confluent, but sometimes limited by a slight ridge. The main tubercles are prominent and of peculiar shape: the mamelon, circular, flattened, very slightly undercut, with large perforation vertically elongate, rests on a fairly wide platform with slight parapet; from the edge of this the boss slopes steeply downwards in a convex curve

[1] *Exceeding noble,* to express the relation to *T. subnobilis.*

which is rather suddenly changed to a concave curve, and this again into a convexity ending in a wall that rises almost vertically from the flat scrobicule. The effect is that of a basal terrace rounded off (fig. 138, elevation).

There is no scrobicular ring, but the whole extra-scrobicular surface is crowded with tubercles and miliaries in which the following arrangement can be detected (fig. 138). The interradial tract contains two main meridional rows, each consisting of clearly mamelonate and perforate tubercles of two sizes — secondaries and tertiaries — which alternate in sequence, so that one secondary and one tertiary is on each interambulacral plate. Since the plates themselves alternate, a secondary of one column lies at the same horizontal level as a tertiary in the adjoining column. The distinction in size between these secondaries and tertiaries is subject to much variation. But they can be identified by their grouping, for the space between a secondary and the tertiary on the same plate is not so great as that between the same secondary and the tertiary on the next plate in the same column. The mammiform bosses of both secondaries and tertiaries are surrounded by narrow scrobicules, scarcely, if at all, sunk, but rendered clear by the close-set ornament of the remaining space. This consists of miliaries among which are scattered quaternary tubercles, slightly mamelonate. None of these latter bear any definite relation to the primary scrobicules. In the adradial tract, however, as seen in *b*, there seems to be a regular row of miliaries or quaternaries along the margins of the scrobicules, while between them and the adradial margin each plate bears 3 or 4 rather larger (? tertiary) tubercles (fig. 135).

The adradial suture is constructed on the plan described under *T. persimilis*, but there are only about 7 denticles to each interambulacral, which therefore corresponded to about 7 ambulacrals (fig. 136). In the holotype a portion of the transverse suture between the interambulacrals is seen at the aboral margin of a scrobicule; it slopes slightly downwards and inwards, and has a distinct median groove.[1] A similar sutural face, more bevelled, is seen in specimen *b* (figs. 136, 137).

The plates are thin, especially at the edges of the primary scrobicules, but are strengthened at the sutures.

The following are measurements in millimetres:

	a	*b*
Height of interambulacral	2.4	3.15
Width » » (estimated) .	6.6	8.0
Transverse diameter of scrobicule . .	4.4 ?	5.0
Diameter at base of boss	2.0	2.6
» of platform	1.0	1.2
» of mamelon	0.5	0.7
Width of interradial tract	3.3	—
Diameter of a secondary tubercle. . .	0.7	—
Thickness of plate near margin . . ca.	0.5	ca. 0.5

Relations of the Species. — Although the high development of the extrascrobicular ornament suggests at first a Diademoid rather than a Cidaroid, still the nature of the adradial suture inclines one to keep the species in *Triadocidaris* in the absence of definite contrary evidence from the ambulacra. Further the resembl-

[1] For discussion of this structure, see under *Miocidaris* (p. 88).

ance to *T. subnobilis* is so close that, with our present knowledge, the two cannot be separated generically. Unfortunately the systematic position of the latter species is itself uncertain, since it too is known only from interambulacrals. If, however, the choice is confined to *Miocidaris* and *Triadocidaris*, the latter is certainly preferable. Broadly speaking, *T. praeternobilis* continues the line of development represented by *T. persimilis*, *T. subsimilis*, *T. Liagora*, *T. Suessi*, and *T. subnobilis;* it differs from *T. subnobilis* in the same way as that species differs from *T. Suessi.* The depression of the scrobicule, absent from the holotype of *T. subnobilis*, but observed in an unfigured paratype (electrotype in Brit. Mus., E 4798), is intensified in *T. praeternobilis.* The secondary tubercles with their perforated mamelons and manifest scrobicules are better developed in the present species, which is mainly distinguished by the regular arrangement of secondaries and tertiaries; for in *T. subnobilis* no such regularity can be detected, while its secondaries and tertiaries, being relatively smaller, are also more numerous. These distinguishing features can be seen at a glance, even in a small fragment. In *T. praeternobilis* the platform of the primary tubercles appears to be less wide, and the parapet less sharply cut; but these are characters in which individual variation must be allowed for.

The two Bakony species of *Triadocidaris* come at the extreme ends of a continous series of which the intervening terms are found at St. Cassian. Since there is good reason to believe that *T. praeternobilis* occurs at a higher horizon than *T. persimilis* and higher than the St. Cassian beds, it affords some argument that the series, as previously described, is a truly progressive evolutionary series.

Triadocidaris ?, cf. *T. praeternobilis.*

(Plate VI. figs. 139, 140.)

Material. — Three small interambulacrals of peculiar appearance, found in the. Raiblian beds at Jeruzsálemhegy, and lettered *a*, *b*, *c*.

Description of the Specimens. — The plates are all wider than high. *c*, the smallest of them, which is the most complete in outline appears hexagonal or heptagonal; probably it was essentially of the ordinary pentagonal shape with the adradial angles rounded off, as is not unusual. *a*, when complete, must have appeared almost quadrangular, since the interradial margin, which is complete, is straight with only a slight truncation at one corner, probably the adambital; and this truncation is bevelled on the outside. The plates are thickened by an external ridge at the transverse sutures, which are approximately vertical and seem to show occasional traces of grooving. The straighter and longer portion of the interradial suture is also thick and vertical. The adradial margin appears to have been thinner, but presents no traces of definite bevels or denticles.

The tubercle is best preserved in *a*. The mamelon is perforate, circular, depressed, not undercut, and of fair width relative to the diameter of the plate. It rests on a platform of nearly three times its diameter, with a low, broad, rounded parapet. In *b* and *c* the mamelon is broken away and the perforation appears to have been enlarged, so that this platform with its parapet looks like a large mamelon. The boss slopes steeply with a convex curve, which suddenly becomes concave and ends in the rounded edge of an obsolescent basal terrace. Outside this there is neither a distinct scrobicule, nor any ornament other than the slight ridges already mentioned as lying at the upper and lower margins, and an occasional faint suggestion of radiating folds or ridges.

Relations of the Specimens. — There is nothing to prove that these plates belong to a *Triadocidaris;* indeed they do not resemble characteristic plates of any Cidaroid. The tubercle, however, is so much like that of *Triadocidaris praeternobilis,* that these plates might come from the adoral region of an individual of that species.

Triadocidaris cf. *subnobilis?*

Material. — A fragment consisting of portions of three interambulacrals, much weathered as well as obscured by tenacious matrix, from the Raiblian Bed *g* at Cutting IV on the Veszprém-Jutas Railroad.

Description of the Specimen. — Two main tubercles are exposed, the third being hidden by matrix. The mamelon is perforate, relatively small, 0.7 mm. diameter, on a rather broad platform 1.6 mm. diameter, with apparently a slight parapet. From this the bosses slope rather steeply with a concave curve. Scrobicules very slightly, if at all, sunk, elliptical with meridional diameter 3.2 mm, confluent; scrobicular ring probably not strongly marked. Several small mamelonate tubercles are visible.

Relations of the Specimen. — This, when collected by Prof. Laczkó, was labelled by him «*Cidaris* cf. *subnobilis* Münst.», and so I have left it; but it is quite as likely to be *T. praeternobilis.*

Triadocidaris immunita[1] n. sp.

(Plate VI. figs. 141—149.)

Diagnosis. — A *Triadocidaris* with test (probably) depressed; each interambulacral column contains numerous (certainly more than 8) plates, of which the width being taken as 100, the height is from 72 to 50;[2] scrobicules indefinite, non-confluent, but those near the poles are usually contiguous and transversely elliptical, and all are flush or very feebly sunk; distance from centre of tubercle to adradial margin from 37 to 50; approximate diameter of boss from 37 to 31; diameter of mamelon from 20 to 14; platform distinctly wider, flat, or with very slight parapet; no scrobicular ring; extra-scrobicular surface crowded with miliaries of two sizes, which tend to radiate from the tubercle. Transverse sutures of interambulacrals slightly grooved or bevelled, but non-imbricate. About 11 ambulacrals to each ambital interambulacral.

Material. — (*a*) Holotype, adoral portion of an interambulacrum (figs. 141—143); (*b*) a similar, but less complete fragment, marked in ink «IX, 63» (figs. 147—149); (*c*) an isolated interambulacral, large and almost complete; (*d*) a smaller fragmentary plate, referred here with some doubt; (*e*) two interambulacrals, firmly united in meridional series (figs. 144—146); (*f*) two interambulacrals and part of third, similarly united: all these come from the Raiblian beds of Jeruzsálemhegy. (*g*) An interambulacral, closely resembling *c,* from the Raiblian beds a—b of Cutting IV on the Veszprém—Jutas railroad.

[1] *Unfortified,* i. e. with no scrobicular circle or ring.

[2] In each of these measurements the former is the more adoral.

Description of the Specimens. — The plates are all thin in proportion to their area, but not remarkably so. The fragments *a* and *b* are clearly adoral; and that the remaining plates also are from either the adoral or adapical regions, is proved by the angle which the adradial margin forms with the two parallel tranverse margins, as well as by the marked inequality of the orad and apicad interradial margins. The slight differences between the specimens are due partly to their having come from different regions of the interambulacrum, partly perhaps to their derivation from individuals in different stages of growth.

Fragment *a* (fig. 141) contains in its *a* column 3 well-developed main tubercles, which rather rapidly increase in size away from the peristome, also apparently a very small obsolescent tubercle on the peristomial border; its *b* column shows 2 well-developed tubercles, while a third probably underlies a detached plate that covers the adoral end of this column. The 6 or 7 plates that bear these tubercles form a piece of test in which no sutures can be distinguished even with the aid of LOVEN's fluid, while the adapical edges are fractured and correspond with the assumed position of the sutures for only a small distance. This adoral region of the interambulacrum is almost flat, but the wide interradial tract is slightly depressed, while the adradial tracts slope gently to the adradial margin.

In specimen *b* (fig. 149) the union of the plates, though firm, was not so close as in *a*, for their outlines are clearly indicated by depressed sutures, and the boundary of the fragment to a large extent corresponds with the sutural edge of an interambulacral.

Specimens *e* and *f* afford further proof that the transverse sutures of the interambulacrum were not flexible. At the same time a slight bevel can be detected when the margin is well preserved. Thus in *e* the free margin of the smaller plate has a slight bevel facing outwards (fig. 145), and this is carried round the adjacent limb of the interradial margin, which is the smaller limb; the free margin of the larger plate has a bevel facing inwards (fig. 146), but it is not conspicuous, partly because the margin is a little worn. Although these bevels are so slight that they might rather be described as a slight deviation of the suture-face from the vertical, still they are enough to suggest that, in accordance with the general rule of adapical imbrication, the smaller plate is adoral, and consequently that the fragment comes from the adoral region. In the isolated plate *c*, the shorter, i. e. the adpolar, of the transverse suture-faces is slightly grooved, while the longer, adambital one shows no definite bevel; if the grooved margin be rightly regarded as adapical, then this plate is from the adapical region.

The position of the main tubercles on the interambulacrals varies with regard to both the adradial and the adapical margins. Taking the first point, we note that in *a*, if the transverse diameter of each plate be taken as 100, then the distance of the centre of the tubercle from the adradial margin is, in the adoral plate, 42, in the next, 38, and in the next, 37. In both *e* and *f*, which agree fairly well in size and probable position with the second and third plates of *a*, the corresponding ratios are about 47 and 41. From these facts it follows that, in the strictly adoral region, the tubercles assume a more adradial position according as the plates are remote from the peristome. Possibly this tendency continued to the ambitus, but in *c* the ratio is 50, and this suggests that in the adapical region the tubercles became more central. In spite of the ratios, the line of tubercles appears to approach the adradial margin as it nears the peristome; and this appearance is due partly to the great obliquity of the adradial margin, partly to the diminished angularity of the interradial suture causing the centre of each plate itself to come nearer to the adradial margin.

Each main tubercle has a mamelon of fair relative size, its transverse diameter being from 0.14 to 0.2 of the transverse diameter of the plate, while its meridional diameter tends to be rather greater and is never less. In the adoral region the relative size of the mamelon increases towards the peristome, owing to the rapid lessening of the diameters of the plates, while its absolute size increases away from the peristome. The perforation is circular but not always central, thus in *e* (fig. 144) it is shifted towards the adambital margin, and in *c* away from that margin; that is to say, if our previous inference with regard to *c* be correct, the shifting in both cases is adapical. The neck is undercut slightly or not at all.

The boss has a well-marked platform, without parapet in specimens *c* to *g*, with very slight parapet in *b*, and with slightly more defined parapet in *a*; this occasionally shows very faint traces of crenelation. From this the boss slopes at a moderately high angle, with straight, or slightly concave, or waved sides into the flush or feebly sunk scrobicule. The scrobicular circle is not defined, nor is there a scrobicular ring; but the scrobicule merges, often with faint radiating ridges or folds, into the extra-scrobicular surface, which bears miliaries of two sizes. These may be quite irregular, as in *a*, where about 16 are contained in (2.5 mm.)[2]; or may tend to continue the radiating folds just mentioned, as in *e*; or may be rather more regular, especially along the adradial margin, as in *b*, where in the second plate a definite row is formed by 6 equal miliaries. In no case do the scrobicules appear confluent, but they are always separated by miliaries. The scrobicules may be almost circular in the relatively high plates, for example *c*, or elliptical in the lower plates, for example *e*, in which the intertubercular miliaries are reduced to a single thin row.

The adradial margin of each plate is almost straight, if anything with a slight convex curve; it is bevelled on its inner surface, and provided with denticles which die out against a slight, rounded meridional ridge (figs. 143, 146, 147). The number of denticles to a plate, which indicates the number of ambulacrals corresponding with an interambulacral, is about 11 to plates 3 and 4 of *a*, plate 3 of *b*, the larger plate of *e*, and in *c*. Plate 2 of *b* has about $9^1/_2$; and the smaller plate of *e*, 8 or 9. The miliaries on the adradial margin do not correspond with the denticles in either number or position.

In specimens *a*, *c*, and *e*, where the denticles are clearly seen, the structure is essentially the same as in other species of *Triadocidaris:* the denticles on the inner surface are continuous with the projections of the extreme margin; at the adoral end of the suture the denticles die out, while the scolloped margin thickens. In *b*, however, the marginal projections appear to die out soon and to be replaced by depressions, as though there were faint denticles alternating with the marginal projections (fig. 147). This appearance might possibly be held to support Professor Doederlein's view that the denticles correspond with the ambulacrals instead of alternating with them; but this it can only do by contradicting the view that the denticles of the inner surface are homologous with the projecting angles of the margin. Other species, e. g. *Mesodiadema latum*, show this structure more clearly, and prove that the depressions on the inner surface are not depressions between denticles but depressions in the denticles.

The peristomial structures are well preserved in *a*. and rather less so in *b* The margin has a faint convex curve, slightly excavate on the interradius. At the adoral end the meridional ridges of the inner surface abut on the interambulacral processes of the discontinuous perignathic girdle. The margin itself forms a slight thickening or ridge, continuous round the peristomial border of the interambulacrum, and presenting no trace of connection with any ambulacral processes. From this ridge arise the two interambulacral processes, one on each side of the interradius. Each process is subtriangular in plan, having at its adoral end a truncate apex merged in the marginal ridge, from which the processes rise gradually to their broader bases, at the same time diverging slightly. Between the processes is a tract continuous with the marginal ridge and therefore raised slightly above the general level of the inner surface of the interambulacrum. It is subtriangular in outline, having a truncate aboral apex separating the bases of the processes. Viewed from the adambital end of the fragment, the elevated base of each process is seen to arch over a slight excavation in the process itself. (See figs 142, 143, 147, 148).

The following are measurements in millimetres:

	a			*c*	*d*	*e*		*f*	
	*a*1	*a*2	*a*3			small	large	small	large
Meridional diameter of plate	2.9	3.2	3.5	5.5	4.3	3.1	3.5	3.3?	3.7
Transverse diameter of plate .	4.0	5.7	7.0	7.4	?	5.3	6.9	5.5?	7.0
Distance of centre of tubercle from adradial margin . . .	1.7	2.2	2.6	3.7	?	2.5	2.8	2.6	2.9
Approximate diameter of scrobicule: meridional	2.4	2.9	3.5	4.2	?	2.4	3.0	?	?
Approximate diameter of scrobicule: transverse	2.4	3.0	4.0	4.6	?	3.4	4.1	?	?
Approximate diameter of tubercle	1.5	2.0	2.2	—	?	2.2	—	—	—
Diam. of mamelon: meridional	0.8	1.1	1.15	1.5	?	0.9	1.1	1.0	1.1
Diam. of mamelon: transverse				1.35	1.1	0.8	1.0	1.0	1.05
Thickness of plate near margin	—	—	0.7	0.65	0.45	0.5	0.5	?	0.5
Thickness on interradius .	0.9	—	0.6	—	—	—	—	—	—
Thickness at tubercle .	—	—	1.8	—	—	—	—	—	—

In *a*: length of adradial margin of *a* column, comprising 3 well-developed plates, circa 8.7; of *b* column, circa 7.3; thickness at highest point of perignathic processes, 1.9; distance of that point from peristomial border, 2.9.

Relations of the Species. — In the indefinite and flush or feebly sunk scrobicule, and in the tendency of the miliaries to radiate, *T. immunita* differs from other species of *Triadocidaris* and reminds one of the associated fossils referred to *Miocidaris planus* and *Anaulocidaris testudo*. It resembles the latter still further in the grooving and bevelling of the transverse sutures, although it is clear that the plates were not flexibly united as they appear to have been in that species. Other differences from *Anaulocidaris* are that in *T. immunita* the miliaries are coarser and closer, the mamelons are larger and are extended vertically rather than transversely, and the adradial suture is denticulate.

The flattened adoral region of the interambulacrum, with its depressed interradial tract, the width of that tract, and the fine extrascrobicular ornament, all are features that remind one of the Diademina. On the other hand many characters of the species subsequently described as *Mesodiadema margaritatum* are reminiscent of *Triadocidaris*. It has in consequence been a difficult matter to decide where to place these two species; indeed I originally referred specimens *a* and *b* to *Mesodiadema* with a different trivial name, and I am far from claiming the present decision as inevitable.

Miocidaris.

1887. *Miocidaris* L. DOEDERLEIN, «Japanischen Seeigel», p. 40.
1887. *Eocidaris* DESOR [pars], L. DOEDERLEIN, op. cit., p. 39; non A. TORNQUIST (1896), nec J LAMBERT (1900).
1899. *Botiaris* J. LAMBERT, Rev. crit. Paléozool. III, p. 82, April.
1900. *Miocidaris* DOED. em. J. LAMBERT, Bull Soc. Sci. Yonne, LIII (1), p. 44.
1900. *Botiaris* J. LAMBERT, op. cit., pp. 38, 39, 40.

This synonymy does not include all the genera (*Cidaris*, *Archaeocidaris*, *Permocidaris*, etc.), to which various species of this genus have been referred by one author or another. In addition to MÜNSTER (1841), KLIPSTEIN (1843), DESOR (1855), LAUBE (1865), QUENSTEDT (1875), see further:

1855. G. &. F. SANDBERGER, «Die Versteinerungen des Rheinischen Schichtensystems in Nassau». Wiesbaden.
1885. W. WAAGEN, «Palaeontologia Indica, Ser. XIII, Salt Range Fossils, I. Productus Limestone Fossils, 5 .... Echinodermata». Calcutta.
1896. A. TORNQUIST, «Beitr. z. Kenntniss v. *Archaeocidaris*», N. Jahrb. f Mineral., 1896, II, pp. 27—60, pl. IV.
1897. A. TORNQUIST, «Das fossilführende Untercarbon .... in den Südvogesen, III .... Echiniden», Abh. geol. Karte Elsass. V, pp. 723—802, pls. XX—XXII.
1898. E. SPANDEL, «Die Echinodermen des deutschen Zechsteins». Abh. naturhist. Ges. Nürnberg, XI, pp. 17—45 & 48, 49, pls. XII, XIII.

Diagnosis. — A Cidarid of moderate size, with the adradial margin of the interambulacrum sharply bevelled on the inner surface, and usually, if not always, denticulate, thus flexibly imbricating over the ambulacrum. Interambulacral plates relatively few, often wide, with scrobicules circular or elliptic, distinct or confluent, with main tubercles small or of medium size, having crenelate bosses. Podial pores not yoked (?).

History of the Genus. — *Miocidaris* was established by L. DOEDERLEIN (1887, p. 40) with a diagnosis of which the following is a translation: «Triassic and Jurassic Cidaridae of moderate size, with thin test, with edges of ambulacral and interambulacral fields fitting over one another in articular union; primary tubercles small, crenelate; scrobicular areas round, slightly sunk; pores not yoked».

«Species *Klippsteini* [sic], ? *subnobilis* from Trias of St. Cassian, and *amalthei*, *arietis* and others, from Lias and Dogger.»

In accordance with this list it seems advisable to regard as genotype the species first mentioned. There were in 1887 two, if not three, species from the Cassian Beds to which the name *Klipsteini* had been attached, and it is of course to the first-established that the name must be confined, namely to *Cidaris Klipsteini* J. MARCOU, 1847.[1] This, however, heing based on a radiole only, is obviously not the one intended by DOEDERLEIN. The next in date is *Cidaris Klipsteini* E. DESOR (March, 1855, p. 4), based on two interambulacral fragments figured by KLIPSTEIN (1843, pp. 273, 274, pl. XVIII fig. 15, 16) and now in the British Museum (regd. 36512, 36513). These appear to belong to a single species, but it is advisable

[1] For discussion of this species, of which *C. ampla* DESOR 1858 is a synonym, see later, p. 171.

to select 36512, the original of fig. 15, as lectotype. The species is worthy of acceptance, but requires a new name, since *C. Klipsteini* was not available for DESOR. I therefore propose ***Cidaris*** (seu ***Miocidaris***) ***Cassiani*** nom. nov., in honour of the saint. The third form known as *Cidaris Klipsteini* is represented in the collection of the Geologische Reichsanstalt, Wien, by three interambulacrals, two of which were figured by LAUBE (1865, pl. IX, f. 7) under this name. Study of these specimens and of electrotypes of them in the British Museum (E4724) has convinced me that they are not of the same species as the type of *Cidaris Klipsteini* DESOR, and are therefore to be called neither *Miocidaris Klipsteini* nor *M. Cassiani*, although they belong to *Miocidaris*. This form, however, needs no discussion at present, for, in the absence of evidence to the contrary, it must be assumed that DOEDERLEIN would have interpreted *M. Klipsteini* by KLIPSTEIN's figures rather than LAUBE's. The genotype of *Miocidaris*, then, is *M. Cassiani*, of which the lectotype, from the Cassian Beds of St. Cassian, is British Museum No. 36512.

J. LAMBERT (1900) retained the genus, but removed *Cidaris subnobilis* to *Triadocidaris*, and included *Cidaris subcoronata*, which DOEDERLEIN had placed in a separate section, unnamed but numbered 5 and diagnosed thus:

«Triassic Cidarids of moderate size with ribbed edges of the interambulacral field fitting over [the edges of the ambulacral field]; primary tubercles very coarsely crenelate; pores yoked (?!)».

LAMBERT (1900, p. 41) in discussing *Miocidaris Amalthei* says that the genus is «clearly characterised by the obliquity of its adambulacral sutures, and is distinguished from *Triadocidaris* by its crenelate tubercles, the arrangement of its circumapical tubercles, etc».

The diagnosis now given (p. 83) differs from that of DOEDERLEIN only in the omission of the statement that the scrobicules are slightly sunk and in the admission of elliptic as well as circular scrobicules. Further, whereas DOEDERLEIN makes no statement as to the denticulation of the adradial suture, it is here asserted that it is denticulate as a rule.

As regards the depression of the scrobicule, it was scarcely correct of DOEDERLEIN to describe it as slight when KLIPSTEIN definitely said that it was «sehr stark vertieft» in the original of his fig. 15 (the type of the genotype). It is true that in the plates incorrectly assigned by LAUBE to the same species, the depression is not so marked. But, apart from the correctness or incorrectness of the statement, the character is not one that can safely be regarded as diagnostic of a genus. The species which, on other grounds, are herein referred to *Miocidaris* present every degree of variation, from flush to deeply sunk scrobicules.

Still less does it seem possible to restrict a genus to species with circular scrobicules. In *Triadocidaris* we have seen a continuous chain of species, with interambulacrals becoming gradually more compressed, and scrobicules contiguous and then confluent, and indeed single individuals presenting both distinct and confluent scrobicules. We may therefore expect to find similar variation in *Miocidaris*. Under *Triadocidaris* an attempt was made to prove that the increasing ellipticity and confluence of the scrobicules was a phenomenon of progressive evolution, correlated with an increase in the number of interambulacrals in a column. So far as that conception is correct, it must apply equally to other genera, and it results therefrom that a species with the ambital scrobicules elliptic and confluent cannot be the ancestor of one in which they are circular and distinct. But if the species with confluent scrobicules occurs at an earlier horizon than the other, obviously it cannot be its descendant. Are the two species, on that ground alone, to be placed in different genera? If the generic idea is to be restricted to a single line of descent, as is the tendency with workers in some groups, then the answer is «yes». But it does not seem to me that our knowledge of the Echinoidea, or at any rate of the Triassic Echinoidea, is sufficiently complete to render such a restriction practicable. I content myself, therefore, with pointing out that the separation of genera by the shape of their scrobicules could be justified only by some such determination of phylogeny.

The denticulation of the adradial suture, though introduced by DOEDERLEIN into the diagnoses of his group 5 (*Cidaris subcoronata*) and of *Triadocidaris*, was omitted from his diagnosis of *Miocidaris*, whence it might be inferred that the bevelled surface was supposed by him to be smooth. In *M. cassiani*, however, there are denticles: so that whether this be mentioned in the generic diagnosis or not, must depend solely on the value attached to the character. It is possible to imagine an oblique flexible adradial suture without denticulation, either because denticles have not been developed or because they have become obsolete. I should hesitate to remove a species from the genus on such grounds. What may be the case in some of the Liassic representatives of the genus, I do not know; but, so far as the species herein referred to are concerned, the question hardly arises, for there is only a single interambulacral that has a smooth bevelled surface, and even that appearance may be due to weathering. There is, however, some evidence for an evolutionary cycle. Thus, the oldest species, *Miocidaris Keyserlingi* (Geinitz), sometimes has an irregular denticulation (seen in Brit. Mus. E1121), while SPANDEL (1898, pl. XIII, f. 4*b*) has figured broad and short, but more regular denticles; since, however, DOEDERLEIN (loc. cit.) denied the existence of such denticulation in this species, and since no other author has mentioned it, very probably it was not always developed. The interambulacrals from the Wellen-dolomite of the Schwarzwald which QUENSTEDT (1875, pl. LXVII f. 115) referred to *Cidaris grandaeva*, are denticulate, while the same feature is well marked in the St. Cassian species and in *Miocidaris verrucosus* from Bakony. In *M. planus*, however, from the Raiblian of Bakony, the denticles are very faint, and in an unnamed plate, as already mentioned, they seem to have disappeared. All these facts therefore have been introduced into the revised diagnosis in the phrase «usually if not always denticulate».

It is quite possible that the Bakony species indicate a divergent evolution, *M. verrucosus* leading to the stereosomatous Cidarid, *Plegiocidaris*, while *M. planus* may be more closely connected with an early Ectobranchiate such as *Eodiadema*.

It is necessary now to justify the relegation of Eotiaris to the synonymy of *Miocidaris*, especially as some of the Bakony fossils would have been referred to that genus had it been retained. The genus was proposed by LAMBERT (1899) for the reception of *Cidaris Keyserlingi* GEINITZ, removed by him from *Eocidaris* in which it had been placed by most authors. In 1900 (op. cit., pp. 38, 39, 40) LAMBERT also referred *Cidaris grandaeva* to *Eotiaris* provisionally, and pointed out in what way the genus differed from *Triadocidaris*, *Microcidaris* and *Plegiocidaris*. Nevertheless he attempted no diagnosis, but presumbly adopted for it DOEDERLEIN'S diagnosis of *Eocidaris* (1887, loc. cit.), since that was based solely on *C. Keyserlingi*.

It runs as follows: «Palaeozoic Cidaridae of small size, with sharply bevelled adambulacral margin of the interambulacral area. Few coronal plates. Main tubercles small, crenelate. Scrobicules elliptic, rather sunk, confluent; scrobicular ring not marked» Comparison of this with DOEDERLEIN's diagnosis of *Miocidaris* shows that the only distinctive feature in the latter is scrobicules «round». None the less LAMBERT separated the two genera, considering *Miocidaris*, with its circular scrobicules, as a descendant of *Eotiaris* with elliptic scrobicules. The objection to such a reversal of the usual order of evolution has already been explained, and doubts have been cast on the value of the character as a generic criterion. Apart from this, the character is not always so marked as is generally asserted. The scrobicules, it is true, are elliptical, but they are not always confluent, for specimens in the British Museum (E1119, E1121), from the Bryozoan dolomite of Pössneck, show a line of granules separating the larger scrobicules. Search for a more reliable diagnostic discovered the assertion of a difference in the adradial suture, which DOEDERLEIN described as smooth in *Eocidaris Keyserlingi.* It has, however, been shown above that it may be denticulate both in that species and in *C. grandaeva.*

Consequently there appears to be no essential difference between *Miocidaris* and *Eotiaris.*

It is perhaps advisable to explain that the genus Eocidaris is in no way affected by this conclusion. Following A. TORNQUIST (1896 and 1897) and J. LAMBERT (1900), I find that *Eocidaris* DESOR has become restricted to *E. laevispina* and *E scrobiculata* alone among the species originally referred to the genus, and I therefore fix on the former of these as genotype, taking as lectotype of the species SANDBERGER's pl. XXXV, f. 2*a* (1855). (See further BATHER, 1908).

It may also be pointed out here that the species *Archaeocidaris Verneuilana* King, which LAMBERT has referred to his genus *Permocidaris* (1900), is closely allied to, if not identical with *Miocidaris Keyserlingi*, as indeed many authors have believed. This, however, does not bring *Permocidaris* into the synonymy of *Miocidaris*, for it is based on *Cidaris Forbesiana* Koninck, which appears from WAAGEN's description (1885, p. 819) to be quite a distinct genus.

Structure of Miocidaris. — DOEDERLEIN's diagnosis contained the statement «pores not yoked» whereas *Cidaris subcoronata* was said by him to have «pores yoked (?!)». Notwithstanding the inclusion of that species in *Miocidaris*, I have retained the «pores not yoked», partly because the contrary assertion was from the beginning exceedingly doubtful, partly because in an ambulacral fragment from the Pachycardientuffe of the Seiser Alp, found in association with interambulacrals referred by BROILI (1904) to *Cidaris subcoronata*, the pores are not yoked. The statement is, however, liable to correction, for the ambulacra are not yet known in the genotype, *M. Cassiani*, or in *M. Keyserlingi* (including *Verneuilana*), or in various other species.

Little attention has hitherto been paid to the sutures between the interambulacral plates themselves in these Streptosomatous Cidaridae. They are, however, of much interest, for, in *Miocidaris* at any rate, they frequently show signs of a flexible, and to some extent an imbricating, union. (Compare text-fig. 7, p. 60).

SPANDEL (1898, p. 34) has stated that in *M. Keyserlingi* the adoral margin of each interambulacral has a convex curve, and is «nach innen abgeschrägt», while the adapical margin has a concave curve and is «nach aussen abgeschrägt», but with a ridge on the outer limit of the bevel which stops the plate next above it from sliding right over it. Similarly, of the interradial margins the adoral one is «nach innen abgeschrägt» and the adapical one «nach aussen». The correctness of this account depends on the meaning to be attached to «nach innen» and «nach aussen». Now SPANDEL goes on to say that the adradial margin of each interambulacral is «nach innen abgeschrägt», and it is admitted by all that this faces inwards. Therefore it would seem that, according to SPANDEL, the adoral transverse margin has a bevel facing inwards; but this is incorrect. On the other hand SPANDEL's figures (pl. XIII, f. 4 *a* & *b*) are clearly meant to show that the convex adoral margin has a bevel facing outwards; and this is correct. We might therefore translate «nach innen abgeschrägt» as «with a bevel facing outwards», and suppose that in describing the adradial margin SPANDEL had written «innen» for «aussen» by a lapsus calami. Unfortunately the question is further complicated by the statement that «an der äusseren Grenze der Abschrägung des oberen Randes liegt eine Leiste, u. s. w.»; for in his section across an interambulacral (pl. XIII, f. 2) SPANDEL has drawn this ridge on the outer limit of the bevel facing outwards, which we have just decided must be the adoral («untere») margin.

The actual facts, as ascertained from an independent examination of specimens of *Miocidaris Keyserlingi* (Brit. Mus., E1119, E1121), may be thus expressed:

MARGIN —	*adradial*	*adapical*	*adoral*	*apicad-interradial*	*orad-interradial*
BEVEL FACING —	inwards	inwards	outwards	inwards	outwards
NATURE OF SUTURE	transverse denticles	ridge on inner margin, sometimes	ridge on outer margin, usually.	smooth	smooth

Essentially the same structure obtains in *M. Cassiani*, as observed in the lectotype and in Brit. Mus. E8552. It may also be seen in *Miocidaris* sp. (Brit. Mus. E8553) from St. Cassian; in a plate of *Miocidaris* sp. from the Cassian beds of Cserhát; in *Miocidaris planus* from the Raiblian of Jeruzsálemhegy; and in a plate of *Miocidaris* sp. from the same horizon at Cutting I on the Veszprém-Jutas Railroad. QUENSTEDT (1875) does not mention it in *M. amalthei* or *M. arietis*, but if the plates are so cleanly isolated as his figures (pl. LXVII, ff. 3, 5, 6, 21, 55) imply, then the suture must have been a loose one. I have not observed the bevelling in *M. verrucosus*, but the material scarcely warrants an assertion of its absence. In *M. subcoronata*, however, the large plates have almost or quite vertical sutures, with only a faint trace of a median depression; and this perhaps shows that DOEDERLEIN was right in separating this species from *Miocidaris*.

The supposition that in all these species the bevel facing outwards is adoral rests partly on my own observations, partly on accepted statements as to the imbrication in Echinoidea generally, and especially on the conclusions of A. TORNQUIST in his excellent «Beitrag zur Kenntniss von *Archaeocidaris*», in which genus the meridional imbrication of the interambulacrals is adapical. Just as the denticulate, overlapping, adradial suture of Triassic Cidaridae is only a stage in phylogenetic development between the similar structure in *Archaeocidaris* and the upright interlocking suture of later Cidaridae, or, in the words of Prof. TÖRNQUIST, «eine letzte ... verschwindende Eigenthümlichkeit der mit verschiebbarem Panzer versehenen palaeozoischen Cidariden», so would I maintain that the bevelled sutures between the interambulacrals of *Miocidaris* are a stage between the similar sutures of *Archaeocidaris* and the smooth upright sutures of later Cidarids—another inheritance from the flexible test of Palaeozoic ancestors. But if this be so, the direction of imbrication must be the same. The hypothesis of a progressive evolution in this character is confirmed by the fact that the structures above described appear to be most definite in *Archaeocidaris*, rather less so in *M. Keyserlingi*, still readily seen in *M. Cassiani*, but less marked in *M. planus* and the other Raiblian *Miocidaris*.

According to SPANDEL (loc. cit.) the ridge serves as a stop («Widerlager») for the adjoining plate; but this view is inconsistent with the existence of a ridge on both upper and lower margins. There is more probability in the opinion of TORNQUIST, that the ridge merely marks a groove for the attachment of the uniting ligament, on which view the presence of a ridge would indicate greater rather than less flexibility.

Comparison of the direction of imbrication in *Miocidaris* with the various directions in which TORNQUIST has indicated it in *Archaeocidaris* shows the difference between a form with two columns of plates in the interambulacrum and one with four columns, In the latter case the imbrication of the transverse sutures is adapical; but the resultant of the combined imbrication of the oblique sutures is from the interradius towards the radius, while on the interradius itself the imbrication is nil or indeterminate. In forms with only two columns the imbrication of the transverse sutures remains as before, but the resultant of the oblique sutures is a similar meridional imbrication in the same adapical direction; imbrication at right angles to this is confined to the adradial sutures. (See text-fig. 7, p. 60).

This imbrication, or at least flexibility, of the interambulacral sutures appears a general, if not a universal, character in *Miocidaris*. In *Triadocidaris* on the other hand, I have noticed it only in *T. praeternobilis* and in some plates of *T. immunita*, where the transverse sutures are slightly oblique and grooved. In *T. persimilis* the sutural face is vertical or very slightly oblique, with a faint median depression. It is, no doubt, on account of the less flexible union that complete interambulacra are more common in *Triadocidaris* than in *Miocidaris*. *T. praeternobilis*, as being the latest in the series, is perhaps the last species in which one would have expected to notice this apparently primitive structure. There is, however, good reason to suppose that the structure was carried on into the Diademoids, and *T. praeternobilis*, as we have seen, is distinctly Diademoid in its ornament. In this feature then, as in others that have been noticed, there seems to be a divergence of evolution, flexible sutures persisting in one series, but changing into rigid sutures in another.

Miocidaris in Bakony. — To this genus are referred the following forms: — From the Cassian beds of Cserhát, a doubtful species, designated α, and another rather more like *M. verrucosus*, and designated β; from the Raiblian of Jeruzsálemhegy and Cutting I on the Veszprém-Jutas Railroad, *M. verrucosus* n. sp., *M. planus* n. sp., and an uncertain species designated γ. From Cserhát there also comes part of an ambulacrum, doubtfully referred to this genus, and designated δ

Miocidaris ? sp. indet. α.

(Plate VI. figs. 150—152.)

Material. — Two fragments, a large (*a*) and a small (*b*), of isolated interambulacrals, from the Cassian beds of Cserhát, Leitnerhof.

Description of Specimens. — (*a*) The larger fragment has a relatively small mamelon, with a transverse diameter of 1.3 mm., and a meridional diameter of 1.4 mm.; it is perforate, depressed hemispheroidal, with neck slightly undercut, resting on a wide platform of 2.7 mm. diameter. The platform, which is marked by 13 crenellae, has vertical sides, from which the boss falls away in a straight slope of about 30° to the horizontal. The scrobicule is scarcely, if at all, depressed, and, since there is no trace of any scrobicular ring or extra-scrobicular ornament, its diameter cannot be stated definitely. There may have been some interradial or adradial extra-scrobicular ornament beyond the limits of the fragment; but one of the transverse margins is preserved and shows that there was no intertubercular ornament, for the scrobicules were confluent. The face of this transverse suture is grooved, and the plate has here a thickness of 0.6 mm. (Fig. 152).

(*b*) The smaller fragment has the same general characters. The diameter of the mamelon is 1.25 mm.; that of the platform, 2.5 mm. There are 15 crenellae. The meridional diameter of the plate is 5.3 mm. Only the transverse margins are preserved; of their sutural faces one, presumably the adapical, has a bevel facing inwards, while the other is grooved; the plate here is 0.6 mm. thick. (Figs. 150, 151).

Relations of the Specimens. — In the absence of the adambulacral margin, the crenelate boss suggests a reference to either *Miocidaris* or *Plegiocidaris*; but, since the transverse sutures indicate that the test was still flexible, one decides in favour of the former, streptosomatous genus. If the absence of ornament is merely due to the loss of all the extra-scrobicular tracts, then the fragments may be merely the scrobicular portions of some species with confluent scrobicules, and therefore neither of the Cassian species hitherto described. The Permian species are out of the question. Compared with *M. verrucosus*, the present plates are twice the size of any belonging to that species, while the scrobicule is larger in proportion to mamelon and platform. It seems probable then that the plates belong to an undescribed species; but if they really were devoid of extra-scrobicular ornament, the probability would be a certainty. Obviously, however, such fragments do not warrant the establishment of a new species.

Miocidaris sp. indet. β.

Material. — A fragment of an interambulacral from the Cassian beds of Cserhát, Leitnerhof.

Description of the Specimen. — This consists of the mamelon, part of the boss and scrobicule, and parts of two adjacent scrobicular rings. The mamelon is depressed hemispheroidal with slightly undercut neck, and has diameters of 1 mm. and 0.85 mm. Its perforation is extended in the direction of the greater diameter. Diameter of platform about 1.2 mm. Crenellae not very clear, and about 16 in number. Boss not very high, slopes with a gentle concave curve to the slightly sunk margin of the scrobicule. If the fragment of the scrobicular ring were completed so as to form a circle, and if the tubercles continued of the same size and disposition all round, then there would have been from 20 to 24 imperforate tubercles, alternating with small miliaries. So much of each of the other scrobicular rings as is preserved is composed of similar tubercles interspersed with similar miliaries. The diameter of the scrobicule may be estimated as at least 3.4 mm.

Relations of the Specimen. —Without the evidence of the adambulacral margin, and considering the apparently close union of the two interambulacral fragments, one cannot say certainly that the specimen belongs to *Miocidaris*. Still it would be more unsafe to refer it to *Plegiocidaris*. The fragment is perhaps more like to *M. Cassiani* than to any of the species from Bakony, but the scrobicule appears less sunk, the platform is not so much wider than the mamelon, the scrobicular tubercles are relatively smaller, and the sutural union probably closer.

Miocidaris verrucosus[1] n. sp.

(Plate VI. figs. 153—156.)

Diagnosis. — A *Miocidaris* in which the interambulacrals are about twice as wide as high, with scrobicules contiguous or confluent, but very little or not at all compressed, very slightly sunk, and without distinct scrobicular tubercles; with platform of main tubercle twice as wide as mamelon, and with 12—14 crenellae; with extra-scrobicular surface irregularly crowded with distinctly mamelonate, imperforate tubercles (about $3^1/_3$ to the square millimetre), interspersed with a few smaller tubercles and miliaries; with 4—5 strong denticles on the adradial margin of each plate. Test flattened on adoral surface.

Material. — (*a*) Holotype, a fragment consisting of portions of 4 interambulacrals from Quarry near Cutting I on Veszprém-Jutas Railroad. (*b*) A portion of an interambulacrum, lying in matrix, and consisting of two almost complete interambulacrals and the central portion of a third, from Jeruzsálemhegy. Both are from the Raiblian beds.

Description of Specimens. — The holotype seems to come from the adoral end of an interambulacrum. The peristomial border is preserved, as also the adradial, but the others are imperfect, especially at the adambital end of the fragment. The tubercle at the adoral end is small; that next it a little larger; the third and fourth larger still and of about equal size, so that they may be regarded as normal representatives. The angle which the adradial margin forms with the peristomial border is 135°.

The main tubercles are relatively prominent. Their perforate mamelons are depressed hemispheroidal, with long neck slightly undercut, and their diameter is half that of the platform, which has 12—14 crenellae. The diameter of the mamelon in the third and fourth plates of *a* is 0.5 mm., in *b* is 0.7 mm., the respective platforms being 1 mm. and 1.4 mm. In *a* the crenellae are rather obscure. The slopes of the boss are straight and rather steep in *a*; but in *b*, where the boss is relatively lower, they are concave and soon merge in the floor of the scrobicule. In *a* the scrobicules are confluent but not much compressed, both transverse and meridional diameter of that on the third plate being about 2.1 mm. In *b* the scrobicules, though contiguous, are separated by a single line of tubercles, which diminish in size rapidly and almost disappear half-way across the scrobicule. Since

[1] *Warty*, in reference to the abundant ornament.

the meridional diameter of the plate is 2.6 mm., that of the scrobicule is a trifle less. The transverse diameter of the plate is 6.7 mm., and that of the scrobicule 2.7 mm.

The whole extra-scrobicular surface is irregularly crowded with rather small, obscurely mamelonate, imperforate secondary tubercles, interspersed with a few smaller tubercles and miliaries. In the third plate of specimen *a*, the adradial tract, which is about 1.2 mm. wide, and 2.1 mm. high, bears 9 secondary tubercles; the interradial tract is incomplete. In *b*, the plate whose measurements are given above has an adradial tract 1.2 mm. wide, and an interradial tract 2.8 mm. wide. In neither *a* nor *b* can any of the secondary tubercles be distinguished as scrobicular; but in *b* the number of secondaries bounding the scrobicule on the right and left is about 5 on each side.

The adradial margin, which is exposed in *a* alone, is bevelled to a sharp edge on the fourth plate, but comes to lie at a less sharp angle as it approaches the peristome. It bears 4 or 5 strong denticles on each plate.

The peristomial border is thickened, but bears no internal processes.

Relations of the Species. — This is distinguished from the Cassian species of *Miocidaris* by the confluent or closely contiguous scrobicules, in which respect it resembles the Permian species referred by Lambert to *Eotiaris*. From them again it differs in its tuberculation and in the stronger denticles.

Miocidaris planus[1] n. sp.

(Plate VII. figs. 157—159.)

Diagnosis. — A *Miocidaris* in which the interambulacral plates are nearly twice as wide as high, with scrobicules contiguous, flush, surrounded by about 18 relatively small, distinctly mamelonate, imperforate scrobicular tubercles; with platform of main tubercle nearly twice as wide as the mamelon and marked by about 18 crenellae continued as folds down the side; with miliaries coarse, close-set, and irregular in size and arrangement; with adradial margin faintly denticulate.

Material. — (*a*) Holotype, an interambulacral plate; (*b*) a portion of another: both from the Raiblian beds of Jeruzsálemhegy.

Description of Holotype. — A large plate, irregularly pentagonal, with its adradial margin oblique to the transverse margins. Diameter: transverse, 12 mm.; meridional, 6.5 mm.

The main tubercle occupies the greater portion of the plate, and projects 2 mm. above its surface. Its circular mamelon has a meridionally extended perforation, a depressed hemispheroidal summit, and long neck slightly undercut. The diameter of the mamelon is 1.8 mm.; that of the platform, 3.2 mm. There are 18 strong crenellae, and no parapet. The slopes of the boss are straight, and are steeper on the adapical and adoral sides than on the others, so that the base of the boss has a transverse diameter (circa 4.7 mm.) greater than its meridional diameter. The flush scrobicule itself has a transverse diameter of 7.2 mm., and a meridional diameter of 5.3 mm. The scrobicular ring, however, is not elliptical, but consists of an almost straight upper and lower tract adjoining the transverse margins of the plate, a slightly curved radiad tract, and a more curved interradiad

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[1] *Level*, in allusion to the flush scrobicules.

tract. The ring comprises 18 distinctly mamelonate, imperforate tubercles, relatively small and widely spaced, alternating with pairs of miliaries radiately disposed, the adcentral of each pair usually being the smaller. These tubercles and miliaries are fairly clear and regular in the lateral tracts, but are less differentiated in the upper and lower tracts. From the scrobicular tubercles faint folds pass towards the boss and meet slight folds continuing the crenellae; but it is not clear whether these two sets of folds merge, or alternate, or are indifferent. The appearance suggests that in an earlier stage either of individual or racial development, when the scrobicule was circular, each crenella was connected by a fold with each scrobicular tubercle, but that, with the compression and distortion of the ring, this connection became obscured. Further remarks on the relations of tubercles to folds will be found on page 98, the last paragraph under *Anaulocidaris testudo.*

The extra-scrobicular surface is covered with coarse miliaries of varying size. In the adradial tract, which has a transverse diameter of about 2.2 mm., these miliaries are irregular; but in the interradial tract, with a transverse diameter of about 1.1 mm., they tend to run in rows.

The adradial margin is bevelled on the inner surface to a thin edge, and is marked by about 16 faint grooves, separating broad flattened denticles. The other sutural surfaces are slightly bevelled and grooved.

Relations of the Species. — This is another form that exemplifies the difficulty of distinguishing *Eotiaris* from *Miocidaris*; indeed it would have been placed in *Eotiaris* had the retention of that genus proved possible. From the species hitherto assigned to *Eotiaris,* it differs in the scrobicular ring and extra-scrobicular miliaries, and these characters also separate it from *Miocidaris verrucosus.* It is distinguished from *M. Cassiani* by the greater width of the plate, the greater relative size of the mamelon, the flush and sub-elliptical scrobicule, the more prominent scrobicular tubercles, and the less regular extra-scrobicular ornament. In the flush sub-elliptical scrobicule, it approaches the specimen figured by Laube as *Cidaris Klipsteini* (vide supra, p. 84), but in other respects is quite different. From *M. subcoronata* it differs in the shape of the boss, the smaller size of the scrobicular tubercles, the less sunk scrobicule, the width of the plate, and minor points.

Miocidaris sp. indet. γ.

(Plate VII. fig. 160.)

Material. — An interambulacral from the Raiblian beds of Cutting I on the Veszprém-Jutas Railroad.

Description of the Specimen. — The plate is pentagonal, with adradial margin oblique to the transverse axis; the transverse margins curved, one convex the other concave. The convex margin is that towards which the adradial margin slopes; it appears to have been slightly bevelled underneath. The opposite concave margin is grooved. If the convex margin be adapical, and the concave margin adoral, as the bevels lead one to infer, then the convexity and concavity are not in harmony with Spandel's account of *M. Keyserlingi,* which, however, we have already discussed (pp. 86—88) and found inconsistent Of the two interradial sides, that next the convex (adapical) margin is slightly the longer. Transverse diameter of plate, 13.2 mm.; meridional diameter, 8.8 mm.

The main tubercle, of which the centre is 5.5 mm. from the adradial margin and 4 mm. from the concave (adoral) margin, occupies with its scrobicule the greater part of the plate, and projects about 2.1 mm. The perforate mamelon is depressed hemispheroidal, with a diameter of 2.1 mm.; its neck long, slightly undercut, resting on a crenelate platform of 3.2 mm. diameter, with about 18 crenellae. The scrobicule appears slightly sunk and marked with radiating folds, but the appearances are not very clear, owing to weathering and matrix. There is no trace of a scrobicular ring; but outside the scrobicule are irregular miliaries.

The adradial margin shows no trace of denticles, only an elevation parallel to the margin on the inside. It is much worn.

Relations of the Specimen. — In some respects this plate resembles *M. planus*; but its proportions are different: the scrobicule appears relatively wider, and it is hard to suppose that, had there been a scrobicular ring, all traces of it should so entirely have disappeared. The specimen is, without doubt, a *Miocidaris*, but is not well enough preserved to support a specific name.

Miocidaris ?, sp. indet. δ.

(Plate VII. figs. 161—163.)

Material. — Part of an ambulacrum from the Cassian beds of Cserhát (Leitnerhof).

Description of the Specimen. — The fragment contains about 8 ambulacrals on each side. These are distinct, and lie approximately at right angles to the perradius.

The perradial tract bears small, mamelonate, imperforate, non-crenelate main tubercles, one on each ambulacral, therefore forming two alternate rows; and in the space between the rows are miliaries, apparently without regular arrangement. In at least one case these miliaries take the place of a main tubercle. Within this tract the ambulacrals are slightly bent towards the apical pole.

From the perradial tract, the ambulacrum slopes gently to the outer edge of the poriferous tract, whence it slopes more steeply to the margin. The pores are slightly oval transversely, and set obliquely, the inner one being, as is usual, nearer the adoral border of the ambulacral plate than is the outer one. They are neither conjugate, nor separated by any noticeable elevation. The sutures between the ambulacrals are clear, and slightly sunk, but there is no definite groove along them leading from the inner pore. Neither is there any groove or depression between the outer pore and the edge of the ambulacrum, although perhaps the faintest tendency towards such a groove may occasionally be detected. Consequently the outer edges of the ambulacrals have not a double scollop.

On the inner surface (fig. 161) the perradial tract is smooth and shows no sutures. The two pores of each pair lie in a groove, but are not actually connected by the groove, since they are separated by a slight ridge crossing it obliquely.

Width of the ambulacrum	4.0 mm.
» » » perradial tract	1.4 »
Diameter of a main tubercle	0.4 »
Height of an ambulacral	0.45 »

Relations of the Specimen. — This ambulacrum differs from those of *Triadocidaris persimilis* and *T. subsimilis* in the absence of grooves leading from the pores to the adradial margin, and in the absence of a ridge or granule between the two pores of a pair; it resembles *T. subsimilis*, but differs from *T. persimilis*, in the adoral position of the inner pore. Since *T. persimilis* is the only Cidarid from Bakony that has the ambulacrum preserved in association with interambulacrals, the present fragment may have belonged to any of the other species from the same locality, namely Cserhát. Unfortunately those species are represented only by the few isolated interambulacrals described, without specific name, as *Miocidaris* α and β, and by the single obscure plate doubtfully referred to *Plegiocidaris*. Specimens of *Plegiocidaris Cornaliae* and *P. Curioni* from the Kössen beds of Eiseler near Hindelang (Pal. Mus München, and Brit. Mus. E4727, E4728, E4695) have a decided elevation between the pores of a pore-pair, and their main tubercles are closer together. The latter feature is also found in *P. Ombonii* (STOPPANI, Pal. Lombard, III, pl. XIX, f. 6). The Triassic species of *Miocidaris* were all described from interambulacrals, and I have never seen any with ambulacrals. BROILI (1903, p.153) has doubtfully referred to *Cidaris subcoronata*, which may be a *Miocidaris*, a fragmentary ambulacrum from the Pachycardientuf, with «unyoked pores and in the middle a double series of small tubercles». Thus the only evidence available does not contradict the reference of the present ambulacrum to *Miocidaris.*

Anaulocidaris.

1879. *Anaulocidaris* K. A. ZITTEL, «Handb. d. Palaeont., Palaeozool.», I, p. 486.

Since all the previous literature relating to this genus deals only with the radioles, the complete list of references will be given later, in the section on the radioles from Bakony (p. 138).

Diagnosis. — A Cidarid with the adradial margin of the interambulacrum bevelled on the inner surface, but not denticulate. Interambulacral plates thin; main tubercles small, perforate, noncrenelate, and without parapet, basal terrace, or definite scrobicule; no scrobicular tubercles, but an extra-scrobicular ornament of scattered miliaries or minute tubercles, which (in the genotype at any rate) spring from the plate as slight (? obsolescent) ridges radiating from the main tubercle. Main radioles change from remiform to spatuliform, trulliform, and paletiform, as they pass from the adoral surface to the apical pole; the paletiform and trulliform radioles meet by the bevelled edges of their blades so as to form a continuous awning over the supra-ambital region of the tést.

Genotype. —*Anaulocidaris Buchi* (MÜNSTER, sub *Cidaris*), Cassian beds of St. Cassian. The only Bakony species is:

Anaulocidaris testudo[1] n. sp.

Interambulacrals only. (Plate VII, figs. 164—187.)

Diagnosis. — See p. 140. Since plates of the test are known in this species alone, the diagnoses of both this and *A. Buchi* have to be based on the radioles, with which we are not concerned at present.

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[1] The awning of radioles resembles the «testudo», which Roman legionaries formed with their shields when attacking a walled town.

Material. — So far as plates of the test are concerned, we have the following isolated interambulacrals: from Jeruzsálemhegy, six lettered *a*, *b*, *c*, *d*, *e*, *f*, and a seventh on matrix and rather doubtful, lettered *g*; from cutting I on the Veszprém-Jutas Railway, three lettered *h*, *j*, *k*. All these are Raiblian. The holotype has to be selected from among the radioles.

Description of the Specimens. — The plates being remarkably thin in proportion to their area, only the two smaller ones, *d* and *e* (figs. 173, 175), retain their complete outline, and even in them it is rather doubtful. Apparently the larger plates (*a*, *f*, *h*, *k*) were essentially five-sided, the upper and lower margins being parallel, the adradial margin approximately at right angles to them, and the two other sides of unequal length, meeting at an angle to form the margin of the zig-zag interradial suture (figs. 164, 178, 184, 187). Plates *b*, *c*, and *j* may have been five-sided, but owing to fracture the evidence is incomplete. The smaller plates on the other hand (for instance *d*, *e*) appear four-sided, although this may be due to the diminution of one of the interradial sides without its complete suppression. Their upper and lower margins are parallel, the adambulacral margin cutting them at an angle, which presumably increases in slope the nearer the plate is to one or other pole. The single interradial margin likewise cuts the upper and lower margins at an angle, but the direction of the slope presumably depends on whether the plate belongs to the oral or aboral hemisphere. Plates of this shape are more likely to have occurred near the poles.

The sutural margins of the interambulacral plates appear to be constituted thus. Of the upper and lower margins one is bevelled underneath (fig. 166), while the other is either bevelled off on the outer surface, or bevelled in such a way that the bevel does not reach the outer margin but meets a ridge which turns it into a groove (fig. 165). For reasons fully given under *Miocidaris* (pp. 86—88), in the absence of evidence to the contrary, the margin bevelled underneath is regarded as the upper or adapical margin in the present species. In specimens *a*, *b*, *e*, *f*, *h*, & *k* the left-hand margin appears to be the adambulacral; it is bevelled underneath at a gentle slope, which, at least in *a*, *e*, and *j*, appears to end on the inner surface against a slight ridge parallel to the margin (figs. 167, 168, 174). There are no traces of denticles in the specimens from Jeruzsálemhegy, but *j* and *k* show some almost imperceptible traces. The parallel ridge, though less conspicuous than in *Triadocidaris*, may still have served to check the interambulacrals from sliding too far over the ambulacrals. The adradial margin was on the right in *j*, and perhaps in *d*; in *c* its position is uncertain. In *a*, *f*, *j*, & *k*, where the adradial margin is best preserved, it follows a curved or wavy course, similar to that shown in Tornquist's figures of *Archaeocidaris* (1896, p. 47, & pl. IV, ff. 6 & 7); it is also clearly scolloped, and the notches indicate that in *f* there were about 7 or 8 ambulacrals to the plate (fig. 180). In *d* and *e* the interradial margin is single and is vertical. In *a* this margin was probably bent so as to form two sides; of these the only one preserved is vertical. In *b*, *h*, and *k*, where there also seem to have been two sides, each of them is bevelled in the same manner as the adjacent transverse margin (fig. 183).

The primary tubercles. — The centre of the mamelon generally lies a little below half the height of the plate, and usually rather nearer to the interradial than to the adradial margin. Its position varies, as may be seen from the table of measurements. The mamelon is relatively small, its transverse diameter in *a* being 0.13 that of the plate; here, as also in *c, e, f, h, j,* and *k*, the meridional diameter is rather less. The perforation, however, tends to be drawn out meridionally, not horizontally. The surface of the mamelon slopes adorally. The neck is not undercut, but rests on a slight platform, which may surround it (as in *j*), or may be absent on the adapical side (as in *f* and *h*), in which case the neck merges imperceptibly into the boss on that side. On the adoral side, however, the platform is always present, and, though it has no definite parapet, it is hollowed on this side. The boss is steeper on the adapical side, especially when it merges into the neck, and it has on this side a straighter slope; on the adoral side it slopes more gently, with a convex curve, often with a slight median depression continuing the adoral excavation of the platform. It passes into a smooth area, which may be very slightly depressed, but is usually flush, or even (as in *h*) raised, reminding one in the last event of a basal terrace. This scrobicule merges quite gradually and indefinitely into the general surface of the plate.

The extra-scrobicular surface bears miliaries, quite irregularly disposed and forming no definite scrobicular ring. These rise out of the plate in such a way as to appear to radiate from the primary tubercle. Sometimes they are obscurely mamelonate, and may be termed minute tubercles. Their variability of number and arrangement may be gathered from the figures (figs. 164, 169, 170, 173, 175, 178, 184, 187). They appear always to pass round the whole plate, so that the scrobicules, although indefinite, are never confluent.

Measurements in millimetres:

	a	*b*	*c*	*d*	*e*	*f*	*h*	*j*	*k*
Vertical diameter of plate . .	6.4	4.6+	5.7	3.5	3.7	5.5	6.9	7.5	5.9+
Transverse » » » . .	7.5	7.9+	5.8+	5.7	4.6	7.0+	7.7	8.2+	8.1+
Distance of centre of tubercle from adambulacral margin .	4.1	3.6+	3.5	2.7	3.0	3.9	4.2	5.2	3.3
Approximate diameter of scrobicule	3.5	3.7	2.5	2.5	2.5	3.4	3.9	4.0	4.6
Diam. of mamelon, transverse	1.0	1.15	1.0	0.6	0.7	1.2	1.4	1.4	1.2
Diam. of mamelon, vertical .	0.85		0.5	0.6	0.65	0.8	0.9	0.9	1.0
Thickness of plate near margin	0.6	0.7	0.4	0.4	0.5	0.5	0.6	0.6	0.6

Relations of these Interambulacrals to the Radioles described as *Anaulocidaris testudo.* — In the absence of definite and close association of these two structures, the reasons for referring both to a single species may be stated as follows: (1) The plates all come from that horizon and from those two localities which have furnished the largest number of characteristic *Anaulocidaris* radioles. (2) The tenuity of the plates and their loose union cannot be explained as due to abyssal conditions or to any deficiency of lime in the water; they suggest therefore that the animal needed some protection, such as, on our hypothesis, would have been afforded by the awning or «testudo» of radioles. (3) The absence of scrobicular tubercles and the reduction of all extra-scrobicular ornament to miliaries or, as may sometimes have been the case, mere granules devoid of radioles, imply that the protection which in Cidaridae is universally supplied by the subsidiary radioles, was no longer needed; a closely fitting «testudo» would, it is evident, deprive any such radioles of their utility. (4) The peculiar transverse extension of the mamelon, combined with its downward slope, with the vertical extension of its perforation, and with the shape of the platform, is evidence that the radiole borne by it could move in a meridional direction but not from side to side; among the numerous radioles that are known from Bakony, it is only those of *Anaulocidaris*, and more particularly the trulliform radioles, that possess an articular surface bearing witness to such limitation of movement: in fact, the acetabulum of those radioles, which general considerations had already induced me to regard as transversely elongate, presents the closest possible correspondence with the mamelon of these interambulacrals. As will hereinafter be shown, the «testudo» was so constructed that its constituent radioles could be depressed but could not be raised or moved from side to side; an articulation such as we here find was therefore a natural consequence.

The preceding arguments should convince the most sceptical that these interambulacrals did bear the radioles of *Anaulocidaris*. It may, however, be objected that the experienced and eminent founder of the genus himself described as interambulacral plates certain structures which were afterwards proved by others, and admitted by him, to be radioles of the shape here distinguished as paletiform; and I may be reminded that the original diagnosis of the genus drew attention to the «quer-sechsseitiger oder etwas unregelmässiger Form mit abgeschrägten seitlichen und unteren (?) Rändern», and to the «durchbohrte Stachelwarze, die von keinem Höfchen umgeben ist» (Zittel, 1879, p. 486). Why, then, may not these supposed interambulacrals from Jeruzsálemhegy also turn out to be radioles?

The resemblance certainly is remarkable, but it is confined to external form, and that only in a general way. The granules or obsolescent miliaries of the plates are not found on any of the radioles, which for their part have linear striae; the articular surface is a convex mamelon in the plates, but a concave acetabulum in the radioles; the radioles have an annulus and collerette, structures which are quite characteristic and not to be confused with the neck, platform, and boss of any tubercle, least of all with those structures in the present species; the section of the plates (e. g., figs. 167, 180) is quite characteristic and differs from that of any paletiform radiole.

Relations of the Species. — Assuming that these plates are correctly placed with the radioles named *Anaulocidaris testudo*, the only question that arises concerning the species as such is the question of its distinctness from *Anaulocidaris Buchi*. This question can only be discussed on the basis of the radioles, and must be deferred till they have been described. These plates, however, throw light for the first time on a more important problem, namely —

The relations of the Genus. — When it was discovered that the supposed interambulacrals of *Anaulocidaris Buchi* were only modified radioles, and when it was further asserted (e. g. by Doederlein, 1886, N Jahrb. f. Mineral, I, p. 192) that other Cidaridae had radioles similarly modified, then the genus *Anaulocidaris* was hastily dropped, and its genotype resumed its original name — *Cidaris Buchi*. This did not mean that anyone regarded the species as a true *Cidaris*, for even the radioles depart considerably from the normal *Cidaris* type; but, in the absence of coronal plates, it was impossible to say to which, if any, of the Triassic genera it might belong. This then is the first question that has to be answered.

Among the genera of Echinoidea having but two columns of plates in each interambulacrum, the only one with a diagnosis that comes near to admitting the interambulacrals before us is *Triadocidaris.* In all known species of that genus, however, the scrobicules are definite and there are distinct secondary tubercles; some have also tertiary tubercles, and all, except *T. subnobilis* and *T. praeternobilis*, have a scrobicular ring. The very different character of the present plates, even though disagreeing with DUNCAN's diagnosis of the Family Cidaridae (1889, p. 26), might be regarded as merely specific and a natural consequence of the enlarged radioles. That, however, would be admitting a modification of considerable extent, for even *Goniocidaris clypeata,* which DOEDERLEIN introduced to science as «Eine recente *Cidaris Buchi*», has the scrobicular and other tubercles, with their radioles, perfectly well developed. More important than the suppression of tubercles is the nature of the various sutural margins. The adradial suture was indeed bevelled on its inner surface, and perhaps overlapped the ambulacra as in *Triadocidaris*, but it lacked the denticles so characteristic of that genus. The other sutures were more bevelled, and consequently more imbricate and flexible, than in any species of *Triadocidaris.* Hitherto it has not been suggested that the transverse sutures in that genus were anything but vertical. We have, indeed, seen that there was some bevelling and grooving in the Bakony species; but this was not enough to cause the plates to fall asunder on the death and decay of the animal. As for the interradial suture, the bevelling of it which is here seen is not met with in *Triadocidaris.*

All these differences seem to warrant the separation of *Anaulocidaris* from *Triadocidaris* and the other Cidaridae, and its maintenance as an independent genus.

Whether the loose union of the interambulacrals exemplifies the retention of an ancestral character or an apparent reversion to it consequent on the evolution of the «testudo», cannot be decided. Another point of similarity to a possible Palaeozoic ancestor lies in the peculiar nature of the miliaries, for they seem less like ordinary tubercles than the ends of faint ridges radiating from the boss. Just such ridges, merging into tubercles, are characteristic of *Echinocrinus* AG. restr. LAMBERT (synn. *Archaeocidaris* M'COY, *Palaeocidaris* DESOR). The occasional elevation of the scrobicule as a sort of basal terrace is also reminiscent of that genus. These two structures are admirably shown in plate XXII, ff. 2 and 6 of TORNQUIST (1897, Abhdl. geol. Specialkarte Elsass-Lothringen, V., Heft VI).

Plegiocidaris.

1883. *Plegiocidaris* A. POMEL, «Classif. méthodique et genera des Échinides», Thése Fac. Sci. Paris, Alger, p. 109. (Reprint, Paléont. Algérie, Echinodermes, Livr. 1. 1887).

1900. *Plegiocidaris* POMEL, J. LAMBERT, Bull. Soc. Sci. Yonne, LIII (1), p. 40.

1902. *Plegiocidaris* POMEL, J. LAMBERT, «Ech. foss. Barcelone», Mem. Soc. geol. France, Pal., IX, fasc. III, p. 5.

1903. *Plegiocidaris* POMEL, em. L. SAVIN, «Ech. foss. Savoie», Bull. Soc. Hist. Nat. Savoie (2) VIII p. 207. (Author's copy, p. 153).

1904. *Plegiocidaris* POMEL, DELAGE & HÉROUARD, «Traitè de Zool. Concrète,» III, p. 228.

Diagnosis. — A Cidarid of variable size and normal shape, with plates united by rigid suture. Ambulacra flexuous, unigeminal, with a double row of imperforate tubercles, and perradial tract bordered by equal regular miliaries. Interambulacral tubercles few, scrobiculate, crenelate, perforate. Radioles inverticillate, elongate or glandiform, granular or spinose.

When POMEL (1883) founded the genus for «Cidariens» with «Tubercules crenélées, pores unigeminés, bordés de granules égaux et réguliers», he mentioned several species in stratigraphical order, but designated no genotype. LAMBERT (1900) considered that the genus was allied to *Eotiaris*, differing only in the more complete rigidity of the test (p. 40); apparently he placed it in his tribe Rhabdocidarinae (p. 53); he referred to it (p. 44) some ten species, none of which occurred in POMEL'S list. From among these may here be mentioned the Rhaetic species *P. Curionii*, *P. Cornaliae*, and *P. Ombonii* (all of STOPPANI), and *P. senex* LAMBERT. Subsequently (1902), in referring *Cidaris Blumenbachi* MÜNST. to *Paracidaris* POMEL, LAMBERT made *Paracidaris* a subgenus of *Plegiocidaris*.

The diagnosis given above is slightly condensed from that drawn up by SAVIN (1903), who maintained *Plegiocidaris* as a subgenus of *Cidaris*, distinct from *Paracidaris*, and definitely selected as genotype *Echinus coronatus* SCHLOTH., which was one of the species mentioned by POMEL

DELAGE and HÉROUARD (1904) speak of *Plegiocidaris*, *Paracidaris*, and *Procidaris*, as allied but independent genera.

Although POMEL included in *Plegiocidaris* species from Trias to Tertiary, no subsequent author has mentioned any species below Rhaetic or above Jurassic. It is probable that the «2 à 3 triasiques» of POMEL were species now referred to *Miocidaris*. The essential difference between the two genera lies in the nature of the sutures, and this, as we have seen, was a character that changed quite gradually. The *Plegiocidaris—Procidaris* series is, however, further distinguished by the increasing size of the ambulacral tubercles, which tend towards the formation of compound ambulacrals. Without the evidence of ambulacrals it is perhaps unsafe to refer to this genus an isolated interambulacral plate, especially from a Cassian horizon. But the existence of the genus at that time is not impossible.

Plegiocidaris? sp. indet.

(Plate VIII. figs. 188., 189.).

Material. — One interambulacral plate from the Cassian Beds of Cserhát, Leitnerhof.

Description of Specimen. — The margins of the plate being broken, its outer measurements are uncertain. The main tubercle has a depressed hemispheroidal, perforate mamelon, with a transverse diameter of 1.15 mm. and a vertical diameter of 1.2 mm.; its slightly undercut neck rests on a platform of circa 1·5 mm. diameter, with about 20 small, rather obscure crenellae. From this the boss slopes, with almost straight, slightly concave sides, to the edge of the scrobicule, which is circular and very slightly sunk, with a diameter of 2.7 mm. There is a scrobicular ring of 20 secondary tubercles, apparently imperforate. The extra-scrobicular surface bears only a few smaller isolated tubercles.

Relations of the Specimen. — As indicated above, it is hard to say whether this belongs to *Miocidaris* or *Plegiocidaris*. So far as specific characters go, it is sufficiently distinguished from all described species of *Miocidaris* by the sparse extra-scrobicular tuberculation. There is no trace of bevelling or denticulation of any of the margins, such as would cause one to refer it to *Miocidaris*; but this might be due to the imperfection of the specimen. The ornament, however, reminds me of some species of *Plegiocidaris*, and it may be noted that a circular scrobicule occupies almost the whole of the plate in *P. Curionii*.

ORDER: DIADEMOIDA.

SUB-ORDER: CALYCINA.

FAMILY ACROSALENIIDAE.

For definitions of the Order, Sub-Order, and Family, see J. W. GREGORY (1900., op. cit. infra, p. 306.)

Eodiadema.

1889. *Eodiadema* P. M. DUNCAN in E. WILSON, Geol. Mag. (n. s.), dec. III, vol. VI, p. 339; Aug.
1889. *Eodiadema* P. M. DUNCAN, «Revision of Echinoidea», Journ. Linn. Soc., Zool., XXIII, p. 81.
1900. *Eodiadema* DUNCAN em. J. LAMBERT, Bull. Soc. Sci. Yonne, LIII, (1) p. 34.
See also:
1900. J. W. GREGORY, «Treatise on Zoology», ed. LANKESTER, III, Echinoderma, p. 308.
1904. Y. DELAGE & E. HÉROUARD, «Traité de Zool. concrète», III, p. 230.
1907. A. R. HORWOOD, Geol. Mag. (n. s.), dec. V, vol. IV, p. 462.

Diagnosis. — An Acrosaleniid with ambulacra composed of simple primaries with unigeminal pores, except in the extreme adoral region where they become arranged in triads and are in part bigeminal; a single perforate tubercle is borne by each ambulacral in the adapical region, but only by the second of each triad in the adoral region. Main interambulacral tubercles perforate, crenelate, slightly eccentric towads the ambulacrum. Other tubercles minute or only miliaries. Apical system extended, hemiolicyclic, the posterior genital being separated from the rest by intercalated oculars.

This diagnosis differs slightly from the lengthy one given by DUNCAN (1889), and still more from the concise one of LAMBERT (1900). It is based on a renewed study of the genotype and of other species.

The genotype is the species described by E. WILSON (1889, loc. cit. supra) under the name «*Eodiadema granulata*» [sic], and depicted by A. S. FOORD in figures 5, 5 *a—c* of pl. X. illustrating the paper by WILSON & CRICK on «The Lias Marlstone of Tilton, Leicestershire» (tom. cit. pp 296—305 and 337—342). The two specimens figured, the only syntypes, are in the collection of the late W. D. CRICK, and have been lent to me through the kindness of Mr. W. CRICK of St. Giles Street, Northampton. Of these two I hereby take the complete test drawn in figs 5, 5 *a* (loc. cit.) as lectotype. According to Mr. A. R HORWOOD (1907) the syntypes and other specimens since found came from the Transition bed between the Middle and Upper Lias, i. e. above the zone of *Amaltheus spinatus*.

Mr. LAMBERT (1900), who was unacquainted with WILSON's description of the genotype, thought it well to select *Echinus minutus* BUCKMAN as «second type du genre». His account of the radioles is doubtless based on that species, and to it also we must look for the explanation of certain important divergences from DUNCAN's diagnosis. Thus, instead of the ambulacrals bearing «très petits tubercules granuliformes [Auct. MS corr. pro «granulifères»]», DUNCAN says that at the ambitus the ambulacrals bear «very small crenulate and perforate tubercles which diminish actinally». Also DUNCAN describes the peristome as «small, and with well-marked branchial incisions». LAMBERT says the converse, but possibly intends the same thing; for words like «small», «faible» and «well-marked» are meaningless to all except their user. In the genotype the diameter of the peristome is circa ·4 that of the test.

DUNCAN placed *Eodiadema* in Diadematidae Orthopsinae. LAMBERT, however, who regards the genus as equivalent to the «Criniferen» of QUENSTEDT (1875, p.

147), places it in a Tribe Eodiademinae of the Subfamily Tiarinae of the Family Diadematidae. GREGORY (1900), who raises the Orthopsinae to the rank of a Family — Orthopsidae, retains *Eodiadema* therein. DELAGE & HÉROUARD (1904), refer *Eodiadema* to their Aspidodiademinae (= Aspidodiadematidae DUNCAN), while placing *Orthopsis* and most of its allies in Pedinidae. GREGORY (loc. cit.) included *Aspidodiadema* in the Orthopsidae, a reference which may or may not be justified; but the action of DELAGE & HÉROUARD seems illogical. For, whatever *Eodiadema* may be, it is undoubtedly, both by time and structure, an ancestral form of the Diadematoid urchins. To comprise such a form together with a couple of recent genera in one Family, while removing all allies and intermediate genera to other Families, could be justified only by the wildly improbable assumption that there existed a long intervening series of Jurassic, Cretaceous, and Tertiary genera of Aspidodiadematidae still completely unknown.

The following are the chief specimens of «*Echinus minutus*» in the British Museum. — E8808—E8812, cotypes of J. BUCKMAN's description in Murchison's «Geology of Cheltenham» p. 95, Edit. II, 1844; Edit. III, 1845, from the Lower Lias, Oxynotus shales, between Cheltenham and Gloucester. E8813, a sixth cotype, appears to be from the second type-locality, the Upper Lias of Alderton Hill, and is probably a different species. E8814, original of T. WRIGHT, Palaeont. Soc. Monogr. Ool. Echin., p. 230. pl. xvii, f. 2. E8815, original of T. WRIGHT, op. cit. pl. xv, f. 3a. E8816, figured and described as *Acrosalenia crinifera* (QUENST.) by T. WRIGHT, Ann. Mag. Nat. Hist. (2) xiii, p. 168, pl. xii, f. 1. All these three are from the Oxynotus shales near Lansdown in Cheltenham. To save future confusion I hereby make E8808 the lectotype of the species. Examination of these specimens inclines me to regard *Echinus minutus* as not congeneric with *Eodiadema granulatum*. But admitting some relationship, I would suggest that these two species at any rate might come at the base of the Acrosaleniidae. DUNCAN said of *Eodiadema*, «The similarity of the genus to *Acrosalenia* is striking»; and WRIGHT placed *Echinus minutus* in *Acrosalenia*. Both species differ from *Acrosalenia* in the simplicity of the ambulacrals, and, in the supposed absence of suranal plates. *E. granulatum*, however, shows a posterior shifting of the periproct while in *E. minutus* the space left by the caducous apical system usually displays an asymmetry that may be due to the same cause.

LAMBERT (1900, p. 35) has referred to the genus, as emended by him, the following species, in addition to the genotype, which is of Upper Pliensbachian age:

Cidaris regularis MÜNST., including *C. Admeto* MÜNST. non QUENST.	Carnian
Pseudodiadema lobatum WRIGHT	Hettangian
Pseudodiadema Collenoti COTTEAU	»
Echinus minutus J. BUCKMAN	Sinemurian[1]
Acrosalenia parva WRIGHT	»[1]
Cidaris laqueatus QUENSTEDT	Pliensbachian
Cidaris octoceps QUENSTEDT	Toarcian
Eodiadema pusillum LAMBERT	»

In making *C. Admeto* a synonym of *C. regularis*, LAMBERT follows the

[1] LAMBERT's reference of these two species to the Charmouthian (= Pliensbachian) was probably a slip.

suggestion of LAUBE (1865, p. 295). But this action has not been based on any study of the unique holotype, for that unfortunately is lost. It may therefore be a valid objection that the original diagnosis of *Cidaris Admeto* by BRAUN in MÜNSTER (1841, p. 40), differs from that of *C. regularis* in the following points: interambulacral plates 6 or 7, instead of 10 to 12; extra-scrobicular ornament of close-set secondary tubercles not much smaller than those of the scrobicular ring, instead of a fine granulation.

Eodiadema ? sp. indet.

(Plate VIII. figs. 190, 191).

Material. — A fragment comprising four plates from the adapical end of an interambulacrum; from the Cassian horizon of Cserhát, Leitnerhof.

Description of the Specimen. — The plates are relatively high and the interambulacrum relatively narrow. Three plates bear well-developed main tubercles, while the fourth has only an incipient tubercle. The main tubercle bears a relatively large, almost hemispherical mamelon, with very small perforation; this is supported on a low boss, of which the platform has about 16 crenellae. There is no scrobicular depression, but the boss seems to rise directly from a field densely covered with miliaries. The adradial margin is clearly scolloped, and bevelled to a thin edge on the inner surface, which bears about 5 slight denticles to each interambulacral.

Relations of the Specimen. — It is the nature of the extra-scrobicular ornament that suggests the reference of this fragment to *Eodiadema*. The relative height of the plates is due to their adapical position. The flexible adambulacral suture has not, it is true, been described in any species assigned to *Eodiadema*, but it may have existed in the earlier ones, especially at the adapical end, which is the last region to be affected by the change to a rigid suture.

SUBORDER: DIADEMINA.

The interambulacral plates which remain for consideration present many difficulties. They fall into three species, two of which certainly and the third probably still possessed loose and to some extent imbricate adradial sutures. They cannot however be kept in the «Streptocidarinae» owing to the nature of their tuberculation, which effectually removes them from the Cidaridae. A place therefore must be found for them among the Regularia Ectobranchiata. Since the tubercles are perforate and non-crenelate, search will most profitably be conducted among those genera which DUNCAN (1889) placed in his Family Diadematidae, GREGORY (1900) in his Suborder Diademina, and LAMBERT (1900) in a Subfamily Pedininae [1] and Tribe Orthopsinae. In none of these has such a loose adradial suture been described, at all events in the adult stage, and it might seem preferable to erect a new genus or new genera for these Triassic species without more ado. Some isolated interambulacrals bearing the name *Hemipedina Bowerbanki* in Wright's handwriting, and now preserved in the British Museum (E 3299), do however show traces of the denticles. In one of the fragments the adradial edge is exceedingly thin, and the denticles faintly visible on the inner surface; this was apparently from the adapical region. In the other

[1] Not the same as the similarly named Subfamilies and Families of DUNCAN and GREGORY respectively, but more the equivalent of Fam. Pedininae in DELAGE and HÉROUARD (1904).

the margin is thicker and clearly bevelled, with the denticles on the bevel; this probably was more adoral in position. These specimens prove that, as was to be expected, there was in the early Diadematidae just the same transition of the adradial suture from flexible to rigid as took place in the Cidaridae. Therefore the interest of the Triassic species lies less in this obvious differentia than in their relation to the known genera of later age, and to place them in fresh genera would not avert the need for a comparison between them and genera already established. Further, the erection of genera on such imperfect material, without certain knowledge of either ambulacra, apical systems, or radioles, would be to court confusion. Consequently it appears the most profitable line of action to refer each new species to that genus which it most resembles in interambulacral structure.

To avoid repetition under each species, we may here run through the Diadematid genera or subgenera with perforate non-crenelate tubercles, and eliminate those which are obviously different or for other reasons are out of court. Thus we may, on *a priori* grounds, at once exclude genera of which no representative older than Cretaceous is yet known We may also legitimately remove from discussion genera in which the pore-pairs are distinctly biserial or triserial, first because it is highly improbable that such a high stage of evolution should have been reached at this period, secondly because such a structure would not harmonise with the denticulate adradial margin. Since we have only interambulacrals before us, comparison must be restricted to those plates, and it will readily be seen from inspection of Figures 192—219 that the Bakony forms cannot well be referred to any of the following genera or subgenera, which are here mentioned without any implication as to their validity or otherwise. They are taken in the order in which they were first proposed.

Leptocidaris QUENSTEDT, 1858, genotype *L. triceps* QUENST., Weisser Jura, certainly seems Diadematid in its ambulacra. The interambulacrals are thin, and though not numerous, are relatively wide and with a fine granulation only on their lateral margins; scrobicules apparently indistinct and confluent.

Cidaropsis COTTEAU 1863,[1] genotype *Hemicidaris minor* AG. 1840, Bathonian and Callovian, has main tubercles large and Cidaroid, separated by a wide extent of intertubercular miliaries.

Miopedina POMEL, 1883, genotype *Hemicidaris Matheyi* DESOR, Bathonian; to it POMEL also refers, without sufficient reason, *Hemipedina tuberculosa* WRIGHT, Corallian. This genus is superficially like *Hemicidaris*; the interambulacrals relatively high, with large main tubercles in the middle of the plates, the extra-scrobicular surface covered with secondaries, tertiaries, and miliaries, which form no very definite scrobicular ring.

Phymopedina POMEL, 1883, genosyntypes *Hemipedina marchamensis* and *H. Bouchardi* WRIGHT, Corallian and Kimmeridgian. This equals WRIGHT's Section II of *Hemipedina*, characterized by 4—10 series of nearly equal tubercles on the interambulacrum.

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[1] DUNCAN (1889, Revision, p. 53) says «Cotteau, 1860 (reference not to be found)». The date 1860 was probably taken from COTTEAU's own statement (Pal. Franc. Jurass. Echin. p. 433, Nov., 1882); but this appears to be a misprint for 1863, which is given, without further reference, in the synonymy five lines lower down. The name was first introduced, without genotype, in a key to the genera of Diadematidae (Pal. Franc. cretac. Echin. p. 374, July, 1863).

Gymnodiadema de Loriol, 1884, genotype *G. Choffati* de Lor., Lower Callovian, has tubercles, and those very small ones, in only two or three rows, adambulacral in position, close to the peristome. The rest of the interambulacrum is covered with sparse miliaries.

Scaptodiadema de Loriol, 1891, genotype *S. Matheyi* de Lor., Rauracian, has relatively small main tubercles without definite scrobicule, but separated by secondaries which cover all the rest of the surface and are rather irregular and unequal.

Phalacropedina Lambert, 1900, with genotype *H. Guerangeri* Cott., a subgenus of *Hemipedina* for «les espèces chauves à hautes plaques, rares granules et tubercules attenués en dessus»; it includes also *H. calva* (Quenst.), ? *H. pusilla* Dames, and ? *H. minima* Cott. The scrobicular circle is far from distinct. Miliaries tend to form scrobicular rings, but are very few in adapical part of test. In the adoral half there are a few secondaries, forming adradial and interradial series, but soon dying out. Oxfordian, Corallian. If this has any genetic value it no doubt represents a small group arising in Oxfordian times.

There now remain *Hemipedina, Diademopsis, Orthopsis, Mesodiadema, Archaeodiadema, Palaeopedina.* Unfortunately the distinction between these forms is by no means easy to grasp, even when all elements of the test are taken into consideration; and it is still more difficult to formulate any differences capable of detection in the interambulacrals alone.

To enter into a complete discussion of these genera would lead us too far afield, and it therefore seems better to reserve the account of my investigations for a more fitting occasion, and meanwhile to take as starting-point the learned and suggestive «Étude sur quelques Échinides de l'Infra-lias et du Lias» by Mr. J. Lambert (1900), who has personally examined most of the type-specimens described by continental authors. Having, however, myself examined the type-specimens of Wright as well as other specimens in the British Museum, I feel warranted in occasionally expressing an opinion different from that of this eminent authority.

Archaeodiadema J. W. Gregory (1896, Geol. Mag. p. 317) may first be disposed of. The only species is *A. Thompsoni* Greg., Upper Lias, Northamptonshire. Lambert (July, 1897, Rev. crit. paléozool.) first considered this as a subgenus of *Diademopsis*, but subsequently (1900, pp. 29—30) as a synonym of *Hemipedina*. With the latter conclusion I agree, but on other grounds than those of Lambert. He supposed the genus to depend on the simple straight series of pore-pairs, and on the imperfect fusion of its majors, leaving free the adapical primary of each triad. The former character was, it is true, selected by Dr. Gregory to distinguish his genus from both *Diademopsis* and *Hemipedina*; none the less, a faint arcuation of the pore-pairs is shown in his own drawing, and, as Lambert points out, the arcuation is no more obvious in many small species of *Hemipedina*: it is, in fact, quite faint even in the genotype, *H. Etheridgei* (holotype, Brit. Mus., E 1593). In many early species usually referred to *Diademopsis* the arcuation is only perceptible quite close to the peristome, e. g. the genotype, *D. serialis*. The second character mentioned by Lambert was not specially described by Gregory, although it is obvious in his figure. He did however utilise the compound nature of the ambulacrals to distinguish *Archaeodiadema* from the Orthopsinae, forgetting that, as had already been noted by DUNCAN (1889, p. 80), precisely the same combination of primary ambulacrals is seen in *Orthopsis* itself, or at least in *O. miliaris* and *O. granularis*, the original species of that genus, though not in other species now referred to it. The diagnostic character that GREGORY did emphasize was the single large main tubercle on the interambulacrals; but in maintaining that *Hemipedina*, no less than *Diademopsis*, possessed two small primary tubercles on each interambulacral, he must have forgotten «the entire absence of secondary tubercles from the areas» of *H. Etheridgei*, as described by WRIGHT (Pal. Soc. Monogr. Ool. Echinoidea, p. 148). It is in fact this character that causes one to associate *A. Thompsoni* with *Hemipedina* rather than with *Diademopsis* or *Orthopsis* as those genera are usually understood. Whatever may be the fate of this species in some future recasting of the Diademine classification, I cannot think that at present Dr. GREGORY has established its claim to be separated generically from *Hemipedina*.

Palaeopedina LAMBERT (1900, p. 22) seems to rest on rather an insecure foundation. The genotype is *Diadema globulus* AG. (in LEYMERIE, 1838), and to the genus are also referred *Diadema minimum* AG. and *Diademopsis Pacomei* COTT. All these are Hettangian. *Hemipedina Bonei* WR., which LAMBERT suggests as a possible member of the genus, is Bajocian. The diagnosis agrees in the main with those given by LAMBERT for *Hemipedina* and *Diademopsis*, but the following are points of difference: — (1) «Test subhemispherical to subglobular»; but *Diademopsis* is said to be sometimes subconical, and not all species of *Hemipedina* are strictly rotular, e. g. *H. Waterhousei*, described by WRIGHT as «inflated», and *H. tuberculosa*, which he calls «hemispherical». (2) «Gill-slits deep,» those of *Hemipedina* and *Diademopsis* being described as feeble. This is a matter of comparison, but I should never have described the slits as feeble in, say, *H. perforata*. (3) «Pore-pairs pseudo-bigeminate near the peristome.» All or nearly all Diademina have those pore-pairs in the stage that LAMBERT calls «pseudotrigéminés», and, since this peculiarity is not alluded to again, I imagine that the latter was the word here intended. (4) «Main interambulacral tubercles nearer to the adambulacral margin than to the median line, accompanied by less developed secondary rows which thin out above»; this is precisely the same as in LAMBERT's diagnosis of *Diademopsis*. (5) «Apical system either dicyclic, with periproct shifted posteriorly by a suranal, or hemiolicyclic (some plates of the second circlet intercalated between those of the first).» This seems to be the real character on which the genus depends, since, in the paragraph following the diagnosis, the presence of a more or less persistent suranal is mentioned as the chief character separating *Palaeopedina* from *Diademopsis* and *Hemipedina*, and on p. 28 it is the only character so mentioned.

First then let us consider the facts as to the occurrence of the suranal in *Palaeopedina*. On p. 25 the suranal of *P. globulus* is said to exist «au moins chez les jeunes», a statement implying that it is not always found in the adult. On p. 26 the evidence is thus summarised: «Usually the position of the suranal is clearly indicated by angularity of the anterior border of the periproct; in some individuals however the suranal has been less developed, and is so to speak confounded with the anal plates in the irregularly circular frame of the periproct.» In *P. minima* the suranal is unknown, but the intercalation of the posterior oculars between the genitals indicates an excavation of the posterior genital by the backward shifting of the periproct, so that the existence of a suranal is probable. In *P. Pacomei* the apex is unknown, but the species is placed in *Palaeopedina* from its resemblance to the genotype. So far, then, the evidence for regarding the suranal as a persistent adult character is not very convincing.

The apex is also unknown in *Hemipedina Bonei,* but that it was caducous and, together with the periproct, extended into the posterior interambulacrum further than in any *Hemipedina* or *Diademopsis* are facts noted by Wright and borne out by the specimens in the British Museum. An independent examination of these specimens, without, for the time being, reference to the literature, convinced me that this species was closely allied to *Pygaster.* In every feature that can be seen, except in the number of tubercle series, it agrees with the diagnosis of that genus. As well as possessing the characters described by Wright, it is somewhat convex on the upper surface and concave at the base; the ambulacral areas are prominent and slightly convex, as in *Pygaster semisulcatus*; in some specimens incipient tubercles are seen just below the ambitus, internal to the main series of ambulacral tubercles; the tubercular ornament, especially on the base, is just as in *Pygaster*; the test has a distinct posterior slope, and the posterior interambulacrum is depressed in the adapical region. It is of course impossible to say definitely that the anus was exocyclic; but it is hard to understand the considerable elongation of the apical space and the depression of the posterior interambulacrum on any other supposition. The smaller number of tubercular series at the ambitus and the less relative width of the interambulacrum are correlated characters indicating an earlier stage of either racial or individual development, and the specimens of *H. Bonei* themselves show differences in this respect. Having observed these points, I was interested to find that Wright himself had been tempted to place the species in *Pygaster* (Monogr. p. 156). Whether it is the young of some known species, such as its associate *P. sulcatus,* which in many respects it resembles, or whether it is an independent species at an earlier stage of evolution, is still hard to decide; but if the species is to be removed from *Hemipedina* it would go with *Pygaster* better than with *Palaeopedina.* Even if it were not far advanced enough to place in *Pygaster,* it would not belong to *Palaeopedina,* for the development of the apical system in *P. globulus* is not in the direction of *Pygaster,* which has no suranal but an encroaching madreporite.

Setting *Pygaster* (or *Hemipedina*) *Bonei* aside, none would contest the importance of Mr. Lambert's observations on *Palaeopedina,* although not everyone will agree that this is «a form of apex in which the more or less prolonged persistence of the central disc has shifted the periproct to the rear». Is it not nearer the truth to say that the passage of the periproct to the rear has involved partial resorption of the posterior genital, while leaving a space to be filled by the increase in size of a periproctal or anal plate, which comes into contact with the growing anterior genitals and so produces angles in the front border of the periproct? The half-formed suranal is not the relic of a pre-existing «disque central»: at least I know of no structure in pre-existing Echinoid genera to which such a term has been or could be applied. If it has any significance it is as showing the mode of origin of the permanent and fully formed sur-anal in the Saleniidae. In itself it can hardly be the fore-runner of the Saleniid sur-anal; at least Mr. LAMBERT for one could not, in fact does not, admit *Palaeopedina* as an ancestor of any member of that Family. In *Pedina*, which seems to be the only possible descendant worth considering, there is no trace of a sur-anal or any similar modification of the apical system. Therefore the change initiated in *Palaeopedina globulus* seems to have led nowhere.

If it were possible to point to certain species as differing obviously from the other early Diademina in the elongation of the periproct and development of a suranal, and at the same time as forming a homogeneous group, one would gladly accept them as a genus. Only one ought, I think, to demand something a little more definite than the evidence of «*Diadema*» *globulus*. But if one were to admit the structure shown in Mr. LAMBERT's figures 4, 5, and 6 as sufficient warrant for a new genus, it would be necessary to point out that the holotype of *Hemipedina Etheridgei* has a precisely similar periproct, and is therefore equally deserving of independent generic rank. But, since that species is the genotype of *Hemipedina*, this would leave a number of species with circular periprocts, but otherwise similar, unprovided with a generic name. I do not propose to take any such action with regard to *Hemipedina*; and for the same reasons I am disinclined to accept *Palaeopedina*.

Orthopsis COTTEAU (Pal. Franc. Cret. Ech. p. 374, July 1863, and p. 550, June 1864) is a perplexing genus. LAMBERT (1900, p. 29) says that it originally comprised four species, of which only two agreed with the diagnosis, so that the type is evidently *Cidarites miliaris* d'ARCHIAC. The four species were *Diadema Repellini* A. GRAS, *D. granulare* AG. & DESOR, *Cidarites miliaris* d'ARCHIAC, and *Pseudodiadema ovatum* COQUAND. Presumably LAMBERT intends to regard *O. granularis* as a synonym of the earlier *O. miliaris*, thus following COTTEAU, PERON, and GAUTHIER (1876, Ech. foss. Algérie, Terr. secondaires, I, p. 213); otherwise the genotype would naturally be *O. granularis*. This however makes only three original species, and it is not clear which of them are the two referred to by LAMBERT; probably he meant to include *O. ovata*. As LAMBERT has well said, *Orthopsis*, at least as usually diagnosed, differs from *Diademopsis* only in the more central position of its main interambulacral tubercles, and the straighter line of its pores. These characters, as well as the less intimate association of the primary ambulacrals into triads, seem so primitive that one is surprised to find them conspicuous in Upper Cretaceous species, but recognised in no species older than Bathonian. If *Orthopsis* is to stand, these characters must be regarded as cases of either arrested or retarded development. If merely arrested, one should find ancestors with the same characters back at least as far as the Lias If retarded, one should be able to prove this by other characters of a more advanced nature.

Taking the first hypothesis, we may remember that *Archaeodiadema Thompsoni* GREG. showed somewhat similar ambulacrals, but since it differed entirely in the tuberculation, it is not one of the ancestors we seek. Not much weight can be attached to the more median position of the main tubercle-series on the interambulacral column in *Orthopsis*, especially when one notices that in the genotype it becomes nearer the adradius above the ambitus, and when one remembers that it is no less median in some admitted *Diademopsis*, e. g. *D. Bowerbanki* (Wr.) and *D. aequituberculata* Lambert. It appears, however, that all recognised species of *Diademopsis* show more arcuation of the pore-pairs around the main ambulacral tubercles, and although we must suppose the existence of a *Diademopsis* ancestor with its pore-pairs in a straight line, there is at present no evidence of any Liassic or Bajocian species reverting to that structure.

Let us then consider the hypothesis that *Orthopsis* is a later reversion, and let us look for any characters forbidding us to regard it as primitive. Such characters are, I believe, to be found in the genotype. Both Cenomanian and Senonian specimens in the British Museum show the following: — In the interambulacrum the convergence of the main tubercle-series as they near the peristome is not nearly so great as in the undoubted species of *Diademopsis* and *Hemipedina* that I have examined. In those genera the tubercles seem almost to meet on the interradius, but in *O. granularis* they remain side by side, with no attempt at inosculation. This seems to indicate a greater extension of the peristome into the interambulacrum, or in other words the resorption of more interambulacral plates: it is a sign of accelerated development. Connected with that character is the wide and straight interambulacral lip, and the rapidity with which the tubercles assume prominence. Below the ambitus the scrobicules of these tubercles are subquadrate, separated only by a line of granules or a ridge, as in *Pygaster*: this also is an advanced character. A striking feature in this species is the adoral position of the main tubercle on each plate and the adapical position of the external and internal tubercles. Thus, the scrobicular circle of the main tubercle invades the plate below, while those of the secondary tubercles invade the plate above. In this way all the tubercles alternate, and so in a column of less relative width than in *Diademopsis* the tubercles are no fewer in number and no smaller in size, for in *Diademopsis* the tubercles are all on the same level. Obviously the alternation is a later stage of development. A slight tendency towards it is seen in *Hemipedina (Phymopedina) Bouchardi*. In the ambulacrum similar scrobicules and a similar alternation of an internal series at the ambitus are observed. At and below the ambitus, each main tubercle, starting apparently from the middle primary of a triad, overlaps the two other primaries equally; but above the ambitus, it is smaller, shifted adorally, and occupies only two primaries, while the adapical primary of the triad bears one or two of the scrobicular tubercles enlarged. This then seems not a simple reversion to a primitive condition, but a step in the direction of increasing the number of tubercles in the main series. Below the ambitus, where the ordinary Diademine relation of the tubercles is maintained, there is still some faint trace of arcuation of the pore-pairs; but above the ambitus this has disappeared with the change in tuberculation. At the peristome the pore-pairs are much crowded and pressed out to both sides in a manner which I have not observed in ordinary species of *Diademopsis* and *Hemipedina*. *Hemipedina Saemanni* Wr. of Rauracian age was referred to *Orthopsis* by P. de Loriol (1884, Rec. Zool. Suisse, I, p. 614) on the evidence of a specimen from Portugal. The holotype (Brit. Mus. E 1501) is poorly preserved, but the alternation of its tubercles was already noted by Wright. The peristome is not exposed. In *Hemipedina microgramma* Wr. doubtfully assigned to the Cornbrash, the much worn holotype (Brit. Mus. 20746 *c*) shows similar remoteness of main tubercles at the peristome and similar alternation of tubercles; here, however, there are two series external to the main one, so that, counting from the adradius, the adapically shifted tubercles are the 2nd. and 4th. The Bathonian *Hemipedina Davidsoni* Wr. has been referred to *Orthopsis* by Pomel, Cotteau, and Lambert; but the holotype (Brit. Mus. E 1667) does not show the above-mentioned characters at all clearly, so that I should regard it as very little, if at all, modified in the direction of a true *Orthopsis*. If, on the other hand, one turns to the Senonian *O. Morgani* and *O. globosa* both of Cotteau & Gauthier (1895, Mission Sci. Perse, pp. 87, 89) and the Maestrichtian *O. perlata* Noetling (1897), one finds similar alternation of interambulacral tubercles, and similar relation of tubercles to the primary ambulacrals. In *O. Morgani* the pore-pairs are said not to multiply around the peristome, but no figure is given. The pore-pairs show a deviation from the straight line; but this does not, as Lambert says, bring it nearer *Diademopsis*, for the deviation is not an arcuation around the main tubercle as in the ordinary Diadematoid type, but is a curve in the opposite direction, and may be regarded as an intensification of the reversion to straightness, and as due to the increased size of the secondary tubercles.

Without discussing other species, of which I have not examined specimens, I feel convinced that there is more to be said for the genus *Orthopsis* than has been said by Lambert or even Cotteau, or than finds a place in any diagnosis yet given. It seems a fair conclusion that *Orthopsis* is a post-Bajocian modification of *Diademopsis*, displaying in its ambulacra a somewhat deceptive appearance of partial reversion to ancestral structure. At any rate — and this is the important corollary on the present occasion — *Orthopsis* is not to be expected from the Triassic rocks.

Hemipedina and *Diademopsis*. — The ground is now clear for consideration of these two genera which, from the very year of their foundation (1855) by Wright and Desor respectively, have greatly troubled systematists. Lambert (1900) makes *Diademopsis* a subgenus of *Hemipedina* on p. 28, but treats it as a genus, with independent diagnosis, on p. 6. Whether as genus or subgenus, it can be justified only if it constitutes a genetic group.

Hemipedina has priority. Wright never distinctly selected a genotype, but Lambert (1900, p. 28) has fixed on *H. Etheridgei*, while Savin (1905, Bull. Soc. Isère, ser. 4, VIII, p. 115) selected *H. tuberculosa*, and might have justified his overriding of Lambert's choice by pointing to Wright's statement (Pal. Soc. Monogr. Ool. Ech., p. 166) that *H. tuberculosa* «forms the best type of that section of the genus, which has two rows of tubercles in the inter-ambulacra, with a wide miliary zone». It is, however, clear from the word «best» that Wright was not here using «type» in the strict systematic sense of «genotype», and since *Pedina Etheridgei* was one of the three species specially mentioned by WRIGHT (Aug. 1855, Ann. Mag. Nat. Hist. ser. 2, XVI, p. 95) as having first suggested to him the establishment of the genus, the action of LAMBERT was justified and cannot now be annulled.[1] Both species fortunately fall into WRIGHT'S Section I.

The genotype of *Diademopsis* appears to have been first fixed by COTTEAU (1884, Pal. franc. jurass. Echin. X, 2, p. 439) as *Diadema seriale* AG. in LEYMERIE; and this is universally accepted. The species first mentioned by DESOR was *Hemicidaris buccalis* AG.

Comparison of the diagnoses given by LAMBERT shows the following points of difference between the two genera.

		Diademopsis	*Hemipedina*
1.	Form of test	subrotular or subconical	rotular
2.	Peristome	subdecagonal	subcircular
3.	Interambulacral main tubercles	eccentric adambulacral	central usually
4.	Secondary tubercles	present but thinning out above	represented only by series of mamelonate granules
5.	Intermediate granules	numerous, subequal, close set	almost always unequal and irregular

It is on points 3, 4, and 5 that LAMBERT lays special stress, and rightly so, for it is quite certain that points 1 and 2 are far from being of universal application. Point 3 is not in itself of great importance, nor can LAMBERT himself regard it as universal, since he describes *Diademopsis aequituberculata* with main interambulacral tubercles «s'élevant au centre des plaques», and admits that they are not always central in *Hemipedina*. The character in any

[1] The systematists who are now endeavouring to establish a rule that the first species referred to a genus by its founder is to be the genotype would deny this statement, since *H. Etheridgei* was not the first. This rule is supposed to leave no room for doubt. Nevertheless in the present instance it is not clear which species is to be regarded as the first. The first species mentioned and described after the establishment of the genus is *H. Bechei* (p. 96); but in an introductory paragraph (p. 95) three species are mentioned as having suggested the establishment of a new genus, and of those species the first named is *Goniopygus perforatus*.

In Science for June 21, 1907, I have pointed out the difficulty of applying this rule to the writings of palaeontologists, who so frequently introduce their species in stratigraphical order, with the usual consequence that the first mentioned is the least characteristic and the most obscure. «*Cidaris Bechei*» is a case in point: probably it is what we now term *Diademopsis*, and its adoption as genotype would still further darken a problem already obscure enough. The selection of *Goniopygus perforatus* would not be so harmful, but the rule in question does not seem intended to apply to any species that a writer may casually mention in his preliminary remarks, unless he at the same time refers it to his genus. *Goniopygus perforatus* was not referred to *Hemipedina* till p. 98.

case is merely a result, in the case of *Diademopsis*, of a greater development of the interradiad secondary series, and in the case of *Hemipedina* of a greater development of the main series. Point 5 is also rather vague and is so qualified as to lose its strict diagnostic value; here again *D. aequituberculata* contravenes the diagnosis.

We fall back, then, on point 4, which may be expressed thus: below the ambitus each interambulacral column has one or more distinct series of secondary tubercles in *Diademopsis*, but has no such distinct series in *Hemipedina*. In a word one may describe *Hemipedina* as pauci-tuberculate, and *Diademopsis* as multi-tuberculate. Let us consider how far this can be taken as a criterion. It is the case that no species of *Hemipedina*, however pauci-tuberculate it may appear, is really devoid of all trace of both an adradial and an interradial secondary series; and this appears to be admitted by the wording of LAMBERT's diagnosis. It is true that the secondary tubercles are hard to detect in such species as *H. Etheridgei, H. Jardinei*, and *H. perforata*; but they are there, and always originate in the same position with regard to the peristome. In *H. Waterhousei* they are slightly more marked, and in *H. Woodwardi* the interradiad series, which reaches just above the ambitus, was large enough to have been mentioned by WRIGHT. In *H. tetragramma* the interradiad series is, at the ambitus, not much smaller than the median series, but higher up becomes quite inconspicuous; the adradial series begins at the peristome as two parallel series of quite small tubercles, of which some become larger towards the ambitus while the others are reduced, and the series thus formed dies out halfway between the ambitus and the apex. This external series was not noticed by DESOR (1858, Synops. p. 430), who however said «Par ses rangées de tubercules accessoires dans les aires interambulacraires, cette espèce forme en quelque sorte le passage des Hemipedina aux Diademopsis». The only reason that I can find why DESOR did not put *H. tetragramma* into *Diademopsis*, is that, as may be gathered from his contemporary statement under *H. microgramma* (p. 433), he placed in *Diademopsis* only species with ambulacral tubercles equal in size to interambulacral, limiting *Hemipedina* to species with the tubercles unequal. It is unnecessary here to trace the introduction of another interradiad series, as in *H.* (*Pseudopedina*) *Smithi*, or of yet another one, as in *H.* (*Phymopedina*) *Bouchardi* and *marchamensis*. Enough has been said to render it clear that there is no obvious reason why a line of generic division based on the number of tubercle-series should be drawn anywhere between *H. Etheridgei* and *H. marchamensis*; or, if one must be drawn, why it should be between *H. Waterhousei* and *H. Woodwardi* rather than between *H. Woodwardi* and *H. tetragramma* — or anywhere else.

There is, however, a reason for drawing a line, although the reason is not obvious and the line must, with our present knowledge, prove doubtful in practice. The Diademina in question are descended from Triassic ancestors, perhaps from Cidaridae, such as *Triadocidaris*. The median tubercle-series certainly corresponds to the unitubercular series of Cidaridae, and the secondary series have arisen by modification of miliaries or of scrobicular tubercles. One would therefore expect to find the pauci-tuberculate species preceding the multituberculate, being in fact their ancestors. This, however, is not the case. There are some early unituberculate species, to which further reference will be made under the name *Mesodiadema*; but the pauci-tuberculate Hemipedinas seem to have originated in Bajocian time, whereas multituberculate Diademopsis are common in the Lias. We have therefore to suppose either a retrogression from *Diademopsis* to *Hemipedina*, which is possible but not probable, or a subsequent and independent evolution of the typical Bajocian *Hemipedina*. Some of the later multituberculate species (*Phymopedina* &c.) may be a further development of *Hemipedina*, or merely a slight modification of *Diademopsis*. On any of these hypotheses *Hemipedina* must be regarded as starting a distinct line of descent.

General principles therefore lead to the acceptance of the two genera *Diademopsis* and *Hemipedina*. At the same time they render the construction of satisfactory diagnoses a still more difficult task. It seems quite probable that *H. Woodwardi* and *H. microgramma* have rightly been regarded as arising within the *Hemipedina* line; but rigid adherence to LAMBERT's diagnoses would place them in *Diademopsis*. So far I have been unable to lay hold of any point by which a true Liassic *Diademopsis* may be distinguished from a multituberculate descendant of a Bajocian *Hemipedina*. The relations of the tubercular series are the same, and although there are differences between different species in regard to the composition of the ambulacra, those differences cannot be grouped in correlation with the tuberculation.

In a recent paper (Bull. Soc. Sci. Yonne, 1905; 1906) Dom Aurélien VALETTE has attempted to separate these two genera according to the width of the interambulacral plates. Presumably the measurements are to be made at the ambitus, but he does not state this. Thus, in *Diademopsis* the width of an interambulacral is more than twice its height, while in *Hemipedina* it is equal to or less than twice the height. Greater width obviously is correlated with increased number of tubercle-series, so that *Diademopsis* is further said to have at least two secondary series to each column, with the tubercles not much smaller than those of the main series, while *Hemipedina* has a large main series with relatively small secondary series. It does not appear, then, that this emphasising of relative width adds anything of importance to the diagnosis: it provides no really fresh character by which one can check the alternative hypotheses as to the ancestry of such species as *H. tetragramma* and *H. marchamensis*. Dom Aurélien, however, also maintains that in all species referred by him to *Diademopsis* the ambulacrals are fully formed majors of three elements, whereas in *Hemipedina* the adapical region of the ambulacrum has sometimes simple primaries, sometimes incompletely formed majors with three granuliferous elements, and sometimes fully formed majors each with a perforate tubercle. Unfortunately the author's division of the species is not consistent with the facts in many cases where I have been able to check it by examination of the type-specimens; therefore it does not help the present discussion. He is, however, justified in pointing out that many species from the Lias and Infralias have more highly developed ambulacra than have several species from later rocks. In this respect also, then, there must have been inequality of development, if not actual divergence. The trouble is that this inequality appears to be quite unrelated to the differences of tuberculation.

In criticising the diagnoses offered by Messrs. LAMBERT and VALETTE, I do not deny the possibility of sorting the species into two groups according to such characters as size of secondary tubercle-series or width of interambulacrals. Evidently any series of objects could be divided by so arbitrary a measure as the ratio of height to width, just as by a sieve. But no evidence has yet been adduced to show that these divisions correspond to genetic groups, and I cannot find that any such correspondence exists. This does not prevent me from believing that there were at least two lines of descent, represented respectively by *Diademopsis serialis* and *Hemipedina Etheridgei*, nor do I suggest that there is any particular difficulty in assigning the pre-Bathonian species to one or other of those series. The difficulty is that the *Hemipedina* series may have produced, and probably did produce, subsequent species which the criteria hitherto suggested do not enable us to distinguish from *Diademopsis.*

The practical outcome of this discussion is the retention of *Hemipedina* (sensu lato), with a diagnosis that shall permit the inclusion of species with any number of interambulacral tubercle-series and with any ratio between the width and height of the ambital interambulacrals. At the same time it is convenient to admit the subgenera *Hemipedina* s. str. and *Diademopsis*, for those earlier paucituberculate and multituberculate species respectively, as to the genetic independence of which there is little room for doubt.

Of the genera that find place in this discussion there is now left only *Mesodiadema.* This, with the species referred to it, will be dealt with independently in the following section; but it may here be pointed out that the interambulacral plates of *Mesodiadema* differ from those of *Diademopsis* in bearing only one primary tubercle on each, and from those of *Hemipedina* in having that tubercle relatively small and unaccompanied by any trace of secondary tubercles. Its ambulacral plates also differ from those of the genera proviously discussed in being all majors with strictly uniserial pore-pairs throughout.

Mesodiadema.

1889. *Mesodiadema* M. NEUMAYR «Stämme des Thierreiches» p. 372.
1900. *Mesodiadema* NEUMAYR, J. LAMBERT, Bull. Soc. Sci. Yonne, LIII (1) p. 31.

In addition to QUENSTEDT, 1875, and DUNCAN, 1889, see also:

1882. P. de LORIOL, Mem. Soc. phys. Genéve, XXVIII, No. 3, p. 8.
1904. Y. DELAGE & E. HÉROUARD, «Traité de Zool. concréte», III, p. 233.
1905. C. AIRAGHI, Atti Soc. Ital. Sci. nat. [= Atti Mus. Milano], XLIV, p. 4.

Diagnosis. — A Diadematoid with ambulacrals never compound or tuberculate, but bearing miliaries; with unigeminal pores; with each interambulacral bearing a perforate, noncrenelate tubercle.

Genotype: *Hemipedina Marconissae* DESOR ex MENEGHINI MS., from the Toarcian, zone of *Terebratula Aspasia*, Tuscany.

The diagnosis is modified from that given by LAMBERT (1900). NEUMAYR (1889) gave the further details: apical system unknown, peristome scarcely notched, general form depressed and like *Pseudodiadema.*

The systematic position of the genus is governed by that of the genotype, which fortunately is fairly well known. NEUMAYR regarded it as a link between Cidaridae and Glyphostomes, placing it provisionally with the latter. Presumably he intended it for an Orthopsid, but he admitted that it might prove to be a Salenid if the apex were known. *Mesodiadema* was not mentioned by GREGORY (1900); but LAMBERT (1900) and DELAGE & HÉROUARD (1904) have placed it in their Pedininae, while no one has ever proposed to place it in the Salenidae.

For the sake of comparison with the Bakony forms, and to get a clearer idea of the general characters of the genus, the species that have been referred to *Mesodiadema* may be briefly considered. With the exception of *M. Marconissae* and *M. Lamberti,* the reference of these species is due to LAMBERT (1900).

(1) *M. Marconissae* (DESOR sub *Hemipedina*). The best description is that by P. de LORIOL (1882). From this we learn that the interambulacra are very wide, consisting of 10—11 plates in a column, each bearing a relatively inconspicuous tubercle, excentric towards the ambulacrum, with a very small mamelon and a wide, rather sunk scrobicule; that the whole extra-scrobicular surface is covered with very fine miliaries, a little unequal, close-set, and forming imperfect scrobicular circles; that the peristome is flush with the test, scarcely at all notched, and extremely small, its diameter not exceeding 0.22 that of the urchin. DE LORIOL's figures 1 and 1*a* are far from clear. In the enlarged figure 1*b* the extra-scrobicular miliaries are not close-set, and the scrobicular ring is more definite than the description leads one to expect; it further appears that the rings are contiguous but distinct, that the scrobicule is slightly sunk at its margin and rises gradually thence to the small mamelon. If the width of an interambulacral as drawn be taken as 100, then the height is 70—78; the distance of the centre of the tubercle from the adradial suture, 39; the width of the scrobicule, 31; the width of the mamelon, 9.5. NEUMAYR's figure of the test seen from the side (though said to be «nach P. de LORIOL») shows the scrobicules quite close to the adradial sutures. It would be well to have these small discrepancies cleared up.

(2) *Cidaris criniferus* QUENSTEDT (1875, p. 156, pl. 67, ff. 99—100), Lias ε of Pliensbach, Wurtemberg, (= Toarcian). The evidence, however, is far from adequate.

(3) *Cidaris olifex* QUENSTEDT (1875, p. 148, pl. 67, ff. 76—88), higher Lias α of Dusslingen (= Sinemurian). At the oral end of each interambulacrum, on the inner surface, is a thickened line representing the perignathic girdle. Thus the peristome slightly approaches pentagonal, but shows no gill-grooves. The adapical half of the test has 5 interambulacrals and 10 ambulacrals in each column [i. e. 2 Amb. to 1 iAmb.], while the oral half has 6 or 7 interambulacrals, making therefore a total of at most 12 interambulacrals. Adapically and about the ambitus the main tubercles are slightly nearer the adradial margin, but adorally they gradually approach the interradius; adapically they become much smaller; they are perforate, «mit undeutlicher Strahlung», and, on the adoral half of the corona, have an incompletely developed scrobicule. Tubercles occur on the perradial tracts of the ambulacra; in the adapical half of the corona they are small, and one is borne by each ambulacral; in the adoral half they are larger, and are borne only by every

second or every third ambulacral. The presence of these tubercles is flatly opposed to the generic diagnoses of NEUMAYR and LAMBERT. The jaws and radioles also are described and figured by QUENSTEDT.

(4) ? *Leptocidaris blaburensis* QUENSTEDT (1875, pl. 69, fig. 71), Kimmeridgian. There is a mistake here, since fig. 71 is *Leptocidaris triceps*, and this cannot be the species intended because the ambulacrals are distinctly majors of 3 elements. Fig. 72 is named *Cidaris blaburensis* in the explanation of the plate, but *Leptocidaris* in the text (p. 233). This appears to show distinct primary ambulacrals, but since the fossil is an internal cast the evidence is not satisfactory, and in any case the appearance is as much like *Cidaris* as *Mesodiadema*.

(5) *Mesodiadema simplex* LAMBERT (1900, p. 31), Middle Lias. Test rotular; diam., 12 mm.; height, 6 mm.; peristome wide; main tubercles 7—8 in column, slightly developed, on adradial border, perforate, noncrenelate, with scrobicules well developed, circular, and contiguous; interradial tract wide.

(6) *Cidaris Admeto* QUENSTEDT (1875, pl. 68, f. 143 non 144) non MÜNST., Carnian, might equally well be *Hemipedina*. The figure is inadequate.

(7) *Mesodiadema Lamberti* AIRAGHI (1905, p. 4, pl. I, f. 3, 3*a*), Middle Lias of Rocchetta near Arcevia. Diam. of test 17 mm., height 8 mm.; diam. of peristome 3.5 mm. Interambulacra very broad; main tubercles, 6 or 7 in column, perforate, scrobiculate, more developed in the adapical half of the corona than in the adoral, where they atrophy and are confused with the general ornament; scrobicules circular, distinct; extra-scrobicular ornament of fine and close-set miliaries. The figures are not clear, and it is not stated which represents the adoral surface, but I take it to be fig. 3. The figures represent the extra-scrobicular miliaries as relatively coarse, and the scrobicules as small and well-marked. The reference of this species to *Mesodiadema* is approved by LAMBERT.

Arranged in order of age the undoubted species of *Mesodiadema* are therefore:

M. Marconissae (DESOR) . .	Toarcian . . .	Italy
M. Lamberti AIRAGHI	Pliensbachian . .	»
M. simplex LAMBERT . . .	Pliensbachian . .	France.

Thus, although *Mesodiadema* is, on morphological grounds, regarded by LAMBERT as the ancestral form of all genera with perforate non-crenelate tubercles (Pedininae), still it has not hitherto been known with certainty below the Middle Lias. It is therefore interesting to find in the Bakony material specimens which, though fragmentary, seem to have a good claim to be placed in this genus. The fragments capable of reference are confined to interambulacrals. The straight and regularly denticulate adradial margins of these fragments indicate that the ambulacrals, and consequently their pore-pairs, were in simple series, but do not warrant the predication that the ambulacrals were non-tuberculate. The interambulacrals, however, agree so closely with those of the recognised species of *Mesodiadema*, not merely in the generic character of perforate, non-crenelate tubercles, but in the position of those tubercles near the adradial margins, the restriction of other ornament to fine close-set miliaries, the considerable relative width of the plates, their combination in one species into an almost flat area denoting a depressed rotular test, and finally the absence in that species of any definite gill-notches on the peristomial border, that it would not be reasonable to refer them to any other genus. In the diagnoses and descriptions which follow, the presence of all these characters is to be understood.

It may, of course, be objected that the reasons for placing these species in the Diadematidae instead of the Cidaridae are insufficient. If placed in the latter Family, they would fall most naturally into *Triadocidaris*, and this would get over any difficulty that may be presented by the denticulate overlapping adradial suture or by the discontinuous perignathic girdle. *Triadocidaris immunita* is not so very different from *Mesodiadema margaritatum* but that the two might be placed in a single genus. It cannot, however, be denied that *M. margaritatum* is far removed from the normal *Triadocidaris*, or that its general external appearance is that of a *Mesodiadema*. It has already been shown that the denticulate adradial suture is no real bar to its position in the Diadematidae. Can one say the same of the perignathic girdle? Undoubtedly this is of Cidaroid type in one of the specimens, and resembles that seen in *Triadocidaris immunita*. In the other specimen, however, there is only a ridge devoid of projections and not unlike that characteristic of Glyphostomata in general (see P. M. Duncan, 1885, J. Linn. Soc., Zool., XIX, p. 179). In the absence of ambulacra it is impossible to say whether ambulacral processes were present or not. On the assumption that the early Diademina were derived from Cidaridae, one would expect to find a gradual change in the perignathic girdle; and a somewhat greater size of interambulacral processes, or a less size of ambulacral processes, would be only natural in any early Diademina. Since there is no published evidence on this point, I have prepared some specimens of *Diademopsis Bowerbanki*, and find that the ambulacral processes are very slightly developed.

It seems reasonable then to regard these Triassic *Mesodiadema* as intermediate between *Triadocidaris* and the later species of *Mesodiadema*. Just as we have already seen that the change from the Streptocidarid type to the Stereocidarid was a very gradual one, so we learn from these species that the change from Cidaridae to Diadematidae was also gradual. It may be that the new types of structure, when once developed, multiplied rapidly; but the more we learn, the more clearly we see that there was no sudden jump.

The existence of these Triassic species confirms the view of those who have regarded this genus as primitive; but it does not prove that *Mesodiadema* was ancestral to such genera as *Hemipedina* and *Diademopsis*. On the contrary, in *Mesodiadema* the suppression of scrobicular and other secondary tubercles inherited from the Cidarid ancestor has advanced far beyond the stage reached in those two genera. In that respect *Hemipedina* (s. str.) is much more like a Cidarid. *Hemipedina (Diademopsis) incipiens* presents a stage from which the later *Diademopsis* may be derived far more readily than from *Mesodiadema*. Some of the ambulacra to be described later show that other primitive Diadematids existed in the Bakony Trias, and it is possible that they were the links that led to *Hemipedina* (s. str.).

The conclusions of this discussion may be summarised, and the evolution of the genera therein mentioned may be provisionally set forth in the following hypothesis: — Beginning with *Triadocidaris*, there was a gradual change from Cidaridae into Diadematidae, a change which may also have recurred at a later stage of Cidarid evolution. *Mesodiadema*, however, appeared early as a streptosomatous form, and gradually assumed stereosomatous characters. The main line of descent tended towards the paucituberculate *Hemipedina*; but, at an early period, some of the subsidiary tubercles were enlarged, and so arose the true *Diademopsis*. *Hemipedina* continued, however, and again gave off a branch with enlarged secondary tubercles to form *Orthopsis*, and another branch to form *Phymopedina*. Some species of *Hemipedina* also showed a tendency towards a posterior movement of the periproct: the earlier of these may be separated as *Palaeopedina*, which led nowhere; but at least one later form, *Hemipedina Bonei*, shows how a continuation of this change initiated *Pygaster*.

Mesodiadema margaritatum[1] n. sp.

(Plate VIII. figs. 192—197.)

Diagnosis. — A *Mesodiadema* with main interambulacral tubercles well developed throughout and having scrobicules pronouncedly confluent, definite, slightly sunk, but devoid of scrobicular ring. The width of an interambulacral being taken as 100, its height is from 25 to 20, distance from centre of tubercle to adradial margin 44 to 41, diameter of boss 15 to 14, diameter of mamelon 7.3 to 5.5. [These measurements are necessarily based on plates of the oral surface, and in each case the former is the more adoral]. Adradial suture denticulate, indicating 3 ambulacrals to an interambulacrum.

Material. — (*a*) Holotype, adoral portion of an interambulacrum from Jeruzsálemhegy (figs. 195—197); (*b*) a similar fragment from Cutting I on the Veszprém-Jutas railroad (figs. 192—194). Both are of Raiblian age.

Description of Holotype. — The *a* column contains 4 well-developed main tubercles, which scarcely increase in size at all away from the peristome, also a partly atrophied tubercle close to the peristomial border. The *b* column contains 5 well-developed tubercles, similar to those in *a*. The 10 interambulacral plates corresponding to these tubercles form a thin, somewhat flattened, piece of test, in which the sutures between the plates are distinguishable as slight grooves; the aboral edge of the fragment corresponds for the most part with the sutures. The wide interradial tract is slightly but clearly depressed, the depression increasing away from the peristome; also the adradial tracts have a marked, rounded slope towards the adradial margin.

The line of tubercles appears to approach the adradial margin as it nears the peristome, although such exact measurements as can be made show that, as in *Triadocidaris immunita*, the more adoral tubercles are really nearer the centres of their plates. (Fig. 195).

Each main tubercle has a minute much depressed mamelon with straight neck. There is scarcely any platform. but the boss starts at once with a convex slope. The scrobicules are depressed, small, and so markedly confluent as to be no longer circular. There is no scrobicular ring, but at the sides the scrobicular circle is definite, since all the extra-scrobicular surface is densely covered with irregular miliaries, of which about 40 are contained in $(2.5 \text{ mm.})^2$. (Figs. 196, 197).

The adradial margin of each plate has a slight convex curve, and on its inner surface bears about 3 slight denticles: two facts which suggest that the ambulacrals may have tended towards a grouping by threes, though not enough to affect the simplicity of the plates or the uniseriality of the pore-pairs. The denticles die out before reaching the meridional ridge, which is very slight. (Fig. 197).

[1] *Pearled*, in allusion to the small, closely set tubercles.

The peristomial margin has a faint convex curve, with a slight but distinct interradial excavation. The matrix on the inner surface prevents one from seeing whether the margin has any thickened ridge. There are seen, however, two strong interambulacral processes, apparently rising rather steeply from the floor of the interambulacrum, then bent sharply over adapically; their precise outlines are obscured by matrix, which has not yielded to several days' work. (Figs. 196, 197).

Description of Specimen *b*. — This is a fragment similar to *a*, but smaller, and obviously from a younger individual of the same species. The *a* column contains 4 fully developed tubercles, and the remains of another on the peristomial border. The inner half of the next interambulacral at the adapical end is also preserved. The *b* column contains 5 fully developed tubercles. The fragment differs from the holotype in the following respects: — The sutures between the interambulacrals are clearer. The interradial depression is a trifle clearer, and comes up to the peristome. The mamelons are distinctly excentric, towards the adapical side of the tubercles. The interradial excavation of the peristome is a trifle more marked. The denticles are not distinct. The perignathic girdle is represented by a ridge continuous across the interradius; no processes are bent over aborally. (Figs. 192—194).

The following are measurements of the two specimens in millimetres:

	Specimen *a*		Specimen *b*	
Length of adambulacral margin of *a* column (4 plates)	4.4		3.2	
» » » » » *b* » (5 plates)	5.1		not preserved	
Measurements of two plates in the *b* column	*1st.*	*5th.*	*1st.*	*5th.*
Heights or vertical diameters	1.0	1.25	0.65	0.85
Transverse diameters	4.1	6.3	2.6	ca. 4.6
Distance of centre of tubercle from margin of plate	1.9	2.2	1.1	ca. 1.8
Diameters of tubercles	0.6	0.9	0.5	0.7
» » mamelons	0.3	9.35	too obscure	

Thickness in the middle of the interambulacrum at the 5th. plate, 0.5. Towards the margin is a considerable thickening and then a sudden thinning; these and other measurements are obscured by matrix. Distance of that point from adoral margin, ca. 5.2. Thickness at highest point of interradial processes in *a*, 3.1.

Relations of the species. — In the lowness of its interambulacrals and the consequent confluence of the scrobicules to such an extent as to render them almost square rather than circular, *M. margaritatum* appears to differ from all the known species of *Mesodiadema*. Other distinctive features that it is possible to mention are: in *M. Marconissae* the imperfect scrobicular ring, the larger relative size of the tubercles and their greater distance from the adambulacral margin; in *M. Lamberti*, the confusion of the tubercles with miliaries on the oral surface; in *M. simplex*, the smaller size, the less numerous and less developed tubercles, which are «au bord adambulacraire».

Mesodiadema lata n. sp.

(Plate VIII, figs. 198—211).

Diagnosis. — A *Mesodiadema* with main interambulacral tubercles well developed, probably throughout, and having scrobicules confluent, slightly elliptical, definite; the area broad and slightly sunk. The width of an interambulacral being taken as 100, its height averages 25 (the extremes are 19 and 40), distance from centre of tubercle to adradial margin averages 47.8 (extremes 34 and 58), transverse diameter of scrobicule averages 33.7 (extremes 25 and 42), diameter of boss averages 16 (extremes 11 and 19), diameter of mamelon averages 7 (extremes 5 and 9). Extra-scrobicular surface covered with distinct regular miliaries, about 4, or fewer, to the millimetre (linear). Adradial margin strongly bevelled, with about 4 denticles to each plate; transverse margins each with a strong rebate.

Material. — This consists of 23 interambulacrals, namely nine from Jeruzsálemhegy (lettered *a—j*), two from Cutting I on the Veszprém-Jutas Railway (lettered *k, l*, the latter labelled as from bed *e*), ten from the quarry near that cutting (lettered *m—v*), one fragment from beds *a—b* of Cutting IV (lettered *w*), and one fragment from Cserhát (lettered *x*). The last two, however, are very doubtful, and will receive a separate description. The rest are all of Raiblian age.

The holotype is specimen *m*. (Figs. 205—207).

Description of Specimens *a—v*. — These plates are markedly distinguished from all other isolated plates found in Bakony by their great relative width (see table of measurements), which may exceed five times their height. The greatest absolute width measured is 9 mm. (in *a*); but in *b* (fig. 201), where the missing adradial tract cannot well have been less than 3 mm. wide, the total width must have been over 10 mm. Specimen *k* was probably wider still.

The next conspicuous feature is the irregular curvature of the plates, which is of two kinds. The coronal plates of all Echinoids necessarily share in the normal curvature of the test. Thus in a perfectly spherical test, did such exist, the transverse and meridional sections of all plates would both be an arc of a circle. When either diameter is short, as is the case with the meridional diameter of the plates before us, this curvature may be neglected. In a long diameter, like the transverse diameter of these plates, the curvature is often obvious, so that the width of the plate measured along its outer surface is appreciably greater than the width measured directly along the chord of the arc. It is the latter measurement that is given in the table. Now in many of these plates, especially the wider ones, the curve is not an arc but is greater on the adambulacral side of the tubercle (figs. 205, 209). As a consequence of this, several of the plates have been broken across by pressure while in the rock, and the adradial portion has either been lost, as in *b* and *j*, or has, though very rarely, been recemented by calcite to the remaining portion, as in *d*. It follows that the interambulacrum as a whole was, at least in its ambital region, flat in the interradial tract and then sharply sloping towards the adradial margin. If one attempts the reconstruction of specimen *b*, one arrives at an equatorial diameter of not less than 32 mm.; how much greater depends on the width of the ambulacra, but 40 mm. would not be unreasonable. One may also infer that the ambitus was pentagonal with rounded angles, i. e. sub-decagonal. Assuming that the interambulacrals of such a test were not higher than specimen *b*, there must have been about 24 in a column.

The second curvature to which reference has been made is seen in specimens *a, c, d, e, f, g, h, k, l, m, n, o, r*, that is in thirteen, while it probably existed in some of the incomplete plates as well, so that about three-quarters of the plates may be supposed to have had it. This curvature is manifested in many ways. In its simplest and commonest form, as in *a, c, h, k, m* (fig. 207), the plate is so bent that its adapical margin is concave, and its adoral margin convex; the greatest concavity is near the tubercle. Another simple form is presented by *d* and *f* (fig. 203), in which the adapical margin is convex and the adoral concave, the concavity being as before near the tubercle. Other plates are less simple, for they have a double curvature, the curve of the adapical margin being concave in one part and convex in another; such are *e*, *g*, *l*, *n*, *o*, and *r* (figs. 199, 202, 208, 204). This double curve exists in various combinations. In one type the adapical concavity is near the tubercle, and, according as the tubercle is remote from or near to the adradial margin, so will that concavity be in the inner or outer half of the plate. Thus *e*, which is from the *a* column, and *g* and *o*, which are from the *b* column, all have the tubercle at about one-third of the distance from the adradial margin; and in them the adradial half of the plate has the adapical margin concave and the adoral convex, while in the interradial half the conditions are reversed (figs. 199, 202). In *r*, on the other hand, which like *o* comes from a *b* column, the tubercle is more interradial, and this portion of the adapical margin is concave, while the adradial half is convex (fig. 204). In the second type of double curvature the adapical margin near the tubercle is convex instead of concave, while the corresponding part of the adoral margin is concave. Thus in *l* and *n*, which are from *a* and *b* columns respectively, the tubercle is remote from the adradial margin, and the adapical margin is convex in its interradial half (fig. 208). Among the various specimens there does not happen to be one in which the tubercle is adradial and the adapical margin convex in that half and concave in the other half; but there seems no reason why such a form should not occur. The varieties of marginal curvature may be tabulated thus:

			Examples	
A. adapical margin concave at the tubercle	1. Single curve	. . . .	*a, c, h, k, m*	= 5
	2. Double curve	*a.* tubercle interradial .	*r*	= 1
		b. tubercle adradial .	*e, g, o*	= 3
B. adapical margin convex at the tubercle	1. Single curve	. . . .	*d, f*	= 2
	2. Double curve	*a.* tubercle interradial .	*l, n*	= 2
		b. tubercle adradial .	none	= 0
			Total	= 13

From this it appears that in each column six varieties are possible, of which all are actually found except *B*, 2, *b*.

The distribution of these varieties in the various regions of the column presents a problem that cannot be solved with the evidence at present available. It can only be pointed out that the variation does not appear to be related in any way to the size of the plates.

The combination of the bending of the plates with the transverse curvature of each plate, and with the normal meridional curvature of the interambulacrum, results in a slight apparent torsion of each plate. This is easily seen when the plate is looked at from one or other of the transverse margins (fig. 205).

Each plate bears a single main tubercle, and the position of this with reference to the adradial margin is variable (see diagnosis and table of measurements) and seems unrelated to the width of the plate. Thus in the plates *c*, *m*, and *o*, each with a width of 7.7 mm., the distance of the centre of the tubercle from the adradial margin is respectively 3.9, 4.5, and 3.1 mm. The mamelon is depressed; the neck, short and undercut; the platform almost flat, but a very slight parapet with a gently rounded edge may sometimes be seen; from this the boss slopes steeply, sometimes with almost vertical sides, and passes into a broad, slightly depressed scrobicule. The scrobicular circle is clearly defined at the sides, but broken at the transverse margins, indicating that the scrobicules were markedly confluent. Its transverse diameter is always greater than its meridional diameter, sometimes nearly twice as great (e. g. specimen *c*); but it is not necessarily greater than the greatest height of the plate (e. g. specimen *f*, fig. 203), for the plate may be reduced in height in the neighbourhood of the tubercle, or in some part the rebate on the adoral margin may project considerably.

The extra-scrobicular surface is covered with miliaries, numerous but distinct, and varying slightly in size; the larger of them in the larger plates (e. g. in *a*) tend to become tubercles, i. e. to be mamelonate. In specimen *a* they are about 4 to 1.4 mm., but rather closer in the adradial tract and more variable in size. In specimen *b* about 4 lie within the height of the plate, viz., 1.3 mm.; here they tend to lie in transverse and meridional rows (fig. 201). In specimen *m* some transverse rows, corresponding with the denticles, are clearly seen in the adradial tract (fig. 207). Although the miliaries come close up to the scrobicule, not any are so distinguished from the others in size or arrangement as to be called scrobicular tubercles.

The adradial margin is distinctly scolloped. The plate, as has been said, is bent down to this margin; but the curvature is more pronounced on the outer surface, with the consequence that the plate thins out gradually towards the margin. This produces the effect of an exceedingly acute bevel on the inner surface, as in *m* (fig. 205). That surface may however have a distinct though slight additional bevel, as in *e* and *g* (figs. 200, 202). In some specimens, as *e*, the limit of the latter bevel is marked by the usual ridge parallel to the adradial margin; this, however, is always faint, and may be entirely absent in other specimens.

The number of denticles on the adradial margin of each plate is 5 or 4, according to the height of the plate. Though not very sharply cut, they are perfectly distinct, and the grooves between them run far back (being often traceable over the ridge) and die away into the surface of the plate. Sometimes the denticles are quite simple, as in *e*, *g*, and *m*; sometimes they are slightly excavate on the inner surface near their adradial ends, as in *r*; sometimes this excavation is more pronounced at a distance from the margin, where it may give rise to hollows which alternate with the grooves and seem to supersede them, as in *o* (fig. 198). These depressions, like those of *Triadocidaris immunita* (p. 81.) are similar to those frequently seen on the main ridges of loose or of articular unions in various Echinoderms, and were probably for the attachment of stroma-strands, either muscular or ligamentar.

The transverse margins are strongly bevelled, but each bevel is stopped by a ridge. In the bevel facing outwards the ridge is on the outer edge; this is taken to be the adoral margin. On the adapical margin, which has its bevel facing inwards, the ridge is on the inner edge. This combination of ridge and bevel may be described as a groove; or, considering the great projection of the bevel, it is better called a rebate. The bevel projects more in the interradial part of the plate, while it almost disappears at the adradial end. If two plates are fitted together, it will be seen that the bevelled surfaces do not meet, but that the bevel of each rests against the ridge of the other. Thus there can have been no regular imbrication, nor can the plates have been tongued together; but there was a loose union, and a space of roughly rectangular section between adjoining plates was presumably filled with stroma.

The interradial margins are bevelled in the same direction as the adjacent transverse margins; but the bevel is not so strong, and there is no ridge (figs. 202, 203).

The mode of union between the plates, combined with their large number (as estimated above), must have produced a test of considerable flexibility.

The following are measurements in millimetres:

	a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*m*	*n*	*o*	*p*
Width	9.0	7.4+	7.7	7.4+	7.3	6.4	6.4	5.4	7.7	7.4	7.7	6.8
Height	2.4	1.3	1.8	2.7	1.4	2.6	1.4	1.4	2.1	2.0	1.5	2.1
Diameter of scrobicule (transverse) . . .	2.7	incomplete	3.2	2.5?	1.9	2.4	1.6	1.8	2.6	2.8	2.6	2.9
Diameter of boss . .	1.3	1.0	1.3	1.5	0.8	1.3	0.8	1.0	1.4	1.4	1.1	1.3
Diameter of mamelon .	0.75	0.5	0.5	0.8	0.4	0.5	0.35	0.4	0.7	0.5	0.4	0.6
Distance of tubercle from adradial margin	3.6	?	3.9	3.7	2.5	3.6	2.5	2.9	4.5	4.3	3.1	3.5
Thickness of plate .	0.45	0.35	0.35 0.6	0.5	0.5	0.5	0.45	0.4	0.5	0.5	0.5	0.6
No. of adambulacral notches	4		3	4?	4	?	4	3	3	3	4	4

Description of Specimen *w* (Fig. 202). — This is from beds *a—b* of Cutting IV on the Veszprém-Jutas Railway, of Cassian age. It appears to be part of a plate from the *b* column, and to consist of the greater part of the interradial tract with a little bit of the scrobicule. The height of the plate is 4.1 mm. The extra-scrobicular ornament consists of small tubercles, irregularly distributed, about 1 mm. apart, with a few minute, but apparently still mamelonate, tubercles here and there between them. The scrobicule is flush. The adapical margin has a slight concave curve, and the adoral margin a corresponding convex curve. The edges are grooved. The plate is 1.2 mm. thick.

Except for its greater size in every way, this fragment closely resembles *M. lata*, and is conveniently described here. If the whole plate were known, it would probably be found to belong to some quite different genus, possibly *Miocidaris.*

Description of Specimen *x*. (Fig. 211). — This is from the Cassian beds of Cserhát. It consists of the tubercle with its scrobicule and a small part of the extra-scrobicular surface. The scrobicule is slightly sunk. The extra-scrobicular ornament consists of close-set irregular miliaries, about 3 to the millimetre (linear). Height of plate 2.3 mm. Diameter of boss, circa 1.3 mm. Diameter of mamelon, 0.5 mm. Adoral and adapical margins bevelled and grooved. Thickness of plate, 0.5 mm.

No difference can be detected between this fragment and one of the larger plates of *M. lata.* If it really is that species, the locality must be considered doubtful.

Relations of the Species. — The absence of any secondary series of tubercles removes this species from *Diademopsis;* and the relatively small size of the main tubercles, coupled with the absence of all tubercles from the extra-scrobicular ornament, removes it from *Hemipedina* (s str.). On the other hand the tuberculation and ornament agree with that of some species referred to *Mesodiadema*, e. g. *M. Marconissae* and *M. Lamberti.* The reference to *Mesodiadema* therefore seems justified.

From the known species of *Mesodiadema*, *M. lata* differs in the greater relative width and probably in the greater number of its interambulacrals.

It is interesting to compare the mode of union between the plates with Duncan's careful description of the structure of the sutural margin in *Diadema setosum* and

Astropyga (1885, Journ. Linn. Soc., Zool., XIX, pp. 98 and 110). DUNCAN seems to regard the union in those recent Diadematids as a kind of dovetailing, a ridge or process of the one plate fitting into a corresponding groove of its neighbour, although he admits that there is also much uniting connective tissue. *M. lata*, however, seems to have had transverse sutures more in agreement with the description given by TORNQUIST of the homologous structures in *Archaeocidaris rossica* (N. Jahrb. f. Mineral., 1906, II, p. 47): «Between the edges of the sutural surfaces is a horizontal groove. This does not serve for the reception of any ridge on the adjacent plate, but the surfaces abut edge to edge, and the groove serves for the attachment of the connective tissue [stroma] which supports the plates».

The width of the plates, their peculiar curvature, and their strong imbrication cannot fail to remind one of the Echinothuridae. A comparison of them with the interambulacrals of *Pelanechinus* is therefore of interest. In that genus, as described by Mr. T. GROOM (1887, Quart. Journ. Geol. Soc., XLIII, p. 703), the infra-ambital interambulacrals resemble those of *Diademopsis* or *Pedina,* but the supra-ambital interambulacrals retain only the main tubercle-series, the rest of the plate being covered with minute tubercles und miliaries; at the same time the plates become curved as in *M. lata*, the concavity in the tubercular and adradial region of the plate being on the adoral margin; finally, whereas the lower plates are closely united by straight sutural edges, those upper ones were flexibly joined and were bevelled so as to produce an adapical imbrication.

It is not contended that *M. lata* was closely related to, or was a direct ancestor of, either *Pelanechinus*, or *Astropyga*, or the Echinothuridae. If in any sense ancestral, there must still have intervened a series of multituberculate and probably stereosomatous forms.[1] But there is an undoubted anatomical resemblance, indicating a physiological similarity.

The Echinothuridae are characteristically abyssal at the present day; their Cretaceous representatives lived at any rate in deep and still waters; but *Pelanechinus* is found in the Corallian of Calne, associated with such a fauna as the word «corallian» connotes. Why this flexibility should have appeared in such environment is hard to say. Equally difficult is it to understand why one Echinoid from Jeruzsálemhegy should manifest similar characters.

Hemipedina.

1855. *Hemipedina* T. WRIGHT, Ann. Mag. Nat. Hist. (2) XVI, p. 95. August.

Genotype: *H. Etheridgei* (WRIGHT, sub *Pedina*).

Subgenus Diademopsis.

1855. *Diademopsis* E. DESOR, Synops. Ech. foss., p. 79, December.

Genotype: *D. serialis* (AG. in LEYMERIE, sub *Diadema*).

In the general discussion of Diademina, the history of these divisions and names has been given at sufficient length, and the sense in which *Diademopsis* is here to be understood has been expounded (pp. 109—113).

[1] See J. W. GREGORY, «On the affinities of the Echinothuridae, &c». Quart Journ. Geol. Soc., LIII, p. 112; 1897.

Hemipedina (Diademopsis) incipiens n. sp.

(Plate IX, figs. 212, 213).

Diagnosis. — A *Diademopsis* with two unequal meridional series of tubercles to each column of interambulacrals, the smaller series being adradial and having more than one tubercle to each plate; also with interradially situate secondary and tertiary tubercles, scrobiculate, and forming an irregular series. Ambulacrals about 5 to an interambulacral.

Material. — A fragment of an interambulacrum from the Raiblian beds of Cutting I on the Veszprém-Jutas Railway.

Description of the Holotype. — The fragment comes from the adoral end of the interambulacrum, and consists of 5 plates of column *b*, with a small interradial portion of the corresponding plates of column *a*. The plates are about four times as wide as they are high. The primary tubercles, one on each plate, form a main series, rapidly increasing in size as it passes from the peristome, but still remaining relatively small. The two main series of the interambulacrum almost meet at the peristome, but diverge rapidly so that on the 5th plate the tubercle is eccentric towards the ambulacrum. The mamelons are rather flattened; the platform does not extend much beyond them and has no distinct parapet. The bosses rise rather steeply from the scrobicules, which are confluent, and not clear, owing in part perhaps to a film of tenacious matrix.

Between the main series and the adambulacral margin is a series of mamelonate and perforate secondary tubercles, of which about 5 correspond to the three larger primaries. These are small and do not greatly increase in size away from the peristome. As it nears the peristome, this series recedes from the adradial margin and approaches the main series. Along the adambulacral border appears to be a row of rather more closely set perforate tertiaries. Between all these tubercles are interspersed miliaries, but their arrangement is obscured by matrix.

The interradial extra-scrobicular space is occupied by mamelonate and perforate secondary and tertiary tubercles, of which the former perhaps were disposed in a meridional series, numerically corresponding to the main series. The miliaries form fairly definite, though usually contiguous, rings round these secondaries, which are thus provided with definite scrobicules. This interradial series does not reach the peristome, but is separated therefrom by the convergence of the primary series.

All the plates and fragments of plates are firmly united, and it is only on the inside of the test that the sutures can be distinguished at all, and even there not clearly (fig. 213). The convexity of the whole fragment is very slight, and this indicates that it came from the under surface of a rotular test.

The adradial margin is almost vertical at the adoral end, but at its adapical end it slopes slightly downwards and inwards. The denticles, which are rather irregular, indicate about 5 ambulacral plates to each larger interambulacral, and pass faintly over the inner edge. There is no ridge parallel to the margin. (Fig. 213).

The peristomial border, measured from the interradius to the adradial margin, has a length of 3.3 mm. Thus the total length of one side of the peristome may be estimated at 6.6 mm. + say 1 mm. for the ambulacrum: total, 7.6 mm. Consequently the greatest diameter of the peristome would have been about 12.5 mm., and the diameter of the test cannot well have been less than 27.5 mm.

The peristomial border is slightly thickened at its adradial end. Between that point and the main tubercular series there is a slight but evident excavation without any distinct rim. Seen from the inner surface the border shows no trace of a perignathic ridge, until a point about corresponding with the main tubercular series, and at 0.8 mm. from the peristomial margin, where there arises a small conical elevation, with its summit at 1.4 mm. from the peristomial margin and about 0.45 mm. above the level of the plate, which is here 0.75 mm. thick. This elevation is probably a relic of the interradial process of the perignathic ridge. (Fig. 213).

The following are measurements in millimetres:

Total height of series of 5 interambulacrals		6.4
Height of largest interambulacral		1.6
Width of largest interambulacral	circa	6.5
Width of its scrobicule	circa	2.2
Width of its tubercle		1.3
Width of its mamelon		0.5
Distance of perforation from adradial margin		3.1
Width of an adjacent secondary scrobicule		1.1

Relations of the Species. — The considerable width of the interambulacrals, namely four times their height, the relative smallness of the main tubercles, the increase in size of the secondary tubercles, and their serial arrangement, cause one to place this fragment in the Diadematidae rather than the Cidaridae. It could not, in fact, be referred to *Eocidaris*, *Microcidaris*, or *Triadocidaris*. The possession of two or perhaps three series of tubercles to each interambulacral column shows that the species must be referred to *Diademopsis* rather than to *Mesodiadema* or *Hemipedina* (s. str.). It is, however, removed from the known species of *Diademopsis* by its more primitive characters: the denticles, the remains of the interradial perignathic process, the poorly developed secondary series of tubercles. This renders the species of much interest, for it is just such a form as we might expect to find at this horizon, on the hypothesis of the independent evolution of *Diademopsis* from a Cidarid like *Triadocidaris*.

Diadematoid ambulacrum, α.

(Plate IX. figs. 214, 215).

Material. — Portion of an ambulacrum on matrix, from bed *i* of Section XI at Jeruzsálemhegy. Cassian age.

Description of the Specimen. — The fragment contains about 24 complete ambulacrals on each side. The length of the whole fragment is 8 mm., but the length occupied by the complete ambulacrals is 6.7 mm., measured along the chord of the curve. The greatest width of the ambulacrum is 3.8 mm.; it decreases slightly adorally. The perradial tract contains a generally alternating double series of large, mamelonate, doubtfully perforate, tubercles, which decrease in size at both ends of the ambulacrum. Between these, and almost surrounding them, are smaller tubercles, varying in size. Where the larger tubercles decrease in size, these smaller ones are more numerous, and sometimes those in line with the larger ones are more prominent The number of larger tubercles in a single row is from 10 to 12, so that one such tubercle approximately corresponds to two ambulacrals. This arrangement, however is not quite regular; especially is it disturbed by the prominent tubercles already mentioned as occurring in the smaller intercalated set. Clearly, certain tubercles of the main meridional series are growing at the expense of the others, and are overlapping the sutures between successive ambulacrals, while the outer portions of the ambulacrals remain quite distinct. The overgrowth seems more pronounced in the ambital region. This specimen therefore strongly corroborates the views first enunciated by LAMBERT (Bull. Soc. Yonne, 1900, p. 8) as to the evolution of majors from primaries; but the stage here attained is more primitive than that of the *Diademopsis serialis* which he there figures, inasmuch as one cannot say that definite majors here exist at all.

The width of the perradial tract is 1.3 mm. at the widest place, and the diameter of a main tubercle is about 0.6 mm. The height of an ambulacral in the same region is 0.3 mm. From the perradial tract the ambulacrum slopes gently at first, and then more steeply. The two podial pores are on the gentle inner slope. The outer slope becomes much more steep adorally, as described under *Triadocidaris persimilis*. The outer limb of each ambulacral plate is directed adapically over the inner slope, and then bends adorally over the outer slope. The pores are transversely oval, the outer one being the more elongate. The inner pore is bounded on its adapical margin by a ridge, and is separated from the outer pore by a slight elevation, but its adoral margin is depressed, and a slight groove passes from it along the suture. This groove, however, thins out as it comes level with the outer pore, for the margin of this pore is elevated all round, though stouter on the adapical side. The sutural groove then widens suddenly just on the angle of the bend, and again thins out towards the outer edge of the ambulacrum. On the outer slope another groove arises at a little distance from the outer pore, and this too becomes less marked towards the outer edge of the ambulacrum. These two grooves do not die out sufficiently to prevent the margin of the ambulacrum being scolloped, with two convex curves to each ambulacral.

Relations of the Specimen. — The outer slope of the ambulacrals bears witness to a flexible adradial suture of the type characterising *Triadocidaris* and *Miocidaris*, while the disposition of the pores and of the grooves leading from them departs but slightly from that described in *Triadocidaris persimilis*. The species, however was evolving, not along the Cidarid line, but along that leading to the Diadematidae.

Diadematoid ambulacrum, β.

(Plate IX, figs. 216, 217).

Material. — Fragment of an ambulacrum from bed *c* 3 of Section VI at Veszprém. Cassian age.

Description of the Specimen. The fragment contains about 19 complete ambulacrals on each side, occupying a length of 5.3 mm. measured along the chord of the curve, which has a short radius. The greatest width of the ambulacrum is 2.5 mm. The interradial tract is ornamented differently in the adapical and adoral regions. In the adapical region, which comprises 7 or 8 ambulacrals on each side, each ambulacral bears a main tubercle, and the space between the two meridional rows thus formed is occupied by smaller tubercles in alternating series, there being one small tubercle immediately adjoining each main tubercle. In the adoral region, which comprises about 12 ambulacrals on each side, the main tubercles are twice the size of those in the adapical region, and each corresponds to two ambulacrals. The appearance is as though every other main tubercle had grown at the expense of its neighbours and of the small tubercle on the same plate as itself, so that there now remain only the alternate main tubercles and the alternate small tubercles, the latter belonging to those ambulacrals from which the main tubercles have been crowded out. The outer limbs of the ambulacrals remain quite distinct.

The width of the perradial tract is 0.9 mm. at the widest place, and the diameter of one of the larger main tubercles is 0.5 mm. The height of an ambulacral in the same region is 0.26 mm. The larger main tubercles are clearly mamelonate and doubtfully perforate. From the interporiferous area the ambulacrum slopes gently at first, and then more steeply. The two podial pores are on the gentle inner slope. The outer slope becomes much more steep adorally. The outer limb of each ambulacral plate lies approximately at right angles to the perradius, and presents no conspicuous curvature. The pores are transversely oval. The inner one appears the larger, or at least the more clearly marked; it is bounded on its adapical margin by a ridge, and is separated from the outer pores by a slight elevation; but its adoral margin is depressed and a slight groove passes from it along the suture. For the rest the form of the pores and their surroundings is just as in α, except that the double scollops on the edge of each ambulacral are not clear.

Relations of the Specimen. — The same remarks as were made under Ambulacrum α are applicable here. This specimen, however, is rather further from *Triadocidaris* and more Diadematoid in the development of its tubercles.

Diadematoid ambulacrum, γ.

(Plate IX, figs. 218, 219).

Material. — Fragment of an ambulacrum from the Raiblian beds of Jeruzsálemhegy.

Description of the Specimen. — This consists of 7 more or less complete ambulacrals on one side, and 8 on the other.

The perradial tract contains large, mamelonate, perforate tubercles, varying in size and arranged rather irregularly, three on one side and three alternating in position on the other. Each tubercle corresponds approximately to 2 ambulacrals (fig. 218). The space between these tubercles along the median line, as well as such space as may occasionally intervene between two successive tubercles, is filled with granules. No sutures are visible in this portion of the ambulacrum.

The two pores of each ambulacral lie in a groove, which appears to extend from the perradial tuberculate tract to the outer edge of the ambulacrum. The pores may therefore be described as conjugate. They appear to be transversely oval. These grooves lie approximately at right angles to the perradius. There is no slope on the inner part of the poriferous tract, but the outer part slopes slightly.

Width of ambulacrum	circa	4.6	mm.
Width of perradial tract	circa	1.7	mm.
Diameter of a large main tubercle		0.9	mm.
Height of an ambulacral		0.47	mm.

The inner surface of the ambulacrum shows no sutures. There is a median flat perradial tract. The poriferous tracts are marked with shallow transverse grooves, which run from the perradial tract to the margin, and correspond with the pore-pairs. (Fig. 219).

Relations of the Specimen. — In the nature of the tuberculation, and in the conjugation of the pores, this ambulacrum seems more advanced than α & β, although the true Diadematid type, with the ambulacrals in triads, is not yet attained.

General remarks on these Ambulacra. — Intermediate as they are between the Cidarid and the Diadematid types, these fossils prove the contemporaneous existence of some primitive Diadematids. In the possession of tubercles they disagree with the diagnosis of *Mesodiadema*, while the distribution of the tubercles is different from that of *Hemipedina* and *Diademopsis*. The difference in this respect between different regions of the same ambulacrum is a clear sign of changing character, the unituberculate primaries showing the road along which the species has travelled, while the growth of certain tubercles and the consequent partial fusion of the ambulacrals into majors point to the direction in which it is going. Here it may be remembered that «*Cidaris*» *olifex* QUENST. has an ambulacrum of similar character (see p. 114), and it is particularly noteworthy that in that species the larger tubercle may be on every second ambulacral as in our specimens. Thus, although it is impossible to connect these ambulacra individually with any of the interambulacrals from Bakony, they lend support to the view that some of those interambulacrals are those of early Diadematids in a similar transitional stage of development. Once again we are forced to the conclusion that the change from Cidaridae to Diadematidae was one that took place slowly by almost imperceptible steps, which can be traced in the life-history of a single individual.

Remains of the Jaw-apparatus.

The Triassic rocks of Bakony have yielded 14 fragments of the lantern, distributed as follows among the various horizons:

	portions of pyramids	rotulae	teeth
Muschelkalk	2	—	—
Cserhát group	—	2	—
Jeruzsálemhegy group .	9	—	1

The peculiarities of this distribution probably depend on the small size of the objects, which renders their collection a matter rather of accident than of design. All these fragments are of the type of structure presented by the recent Cidaridae, but such observations as have hitherto been published do not make it clear that this type is confined to that Family; it might have persisted in the early representatives of the Regularia Ectobranchiata. Therefore speculation concerning the particular genus to which any or all of these fragments may have belonged would have no sure basis. It has nevertheless seemed advisable to give figures and descriptions of these fragments, as materials towards some eventual history of the evolution of this wonderful mechanism. Of course by Triassic times the early stages had long been passed; indeed a well-developed lantern existed already in the Silurian *Palaeodiscus* and *Echinocystis*. But between those early forms and the lantern of a recent *Echinus* there is considerable difference; there are even differences between them and the recent *Cidaris*. A detailed comparative study of this kind of fossil remains might well prove as valuable as the account of recent forms contained in Lovén's «Echinologica». (Bihang K. Svenska Vet.-Akad. Handl. XVIII, Afd. IV, No. 1, July, 1892.)

Note on Terminology. — It may not be out of place to urge upon those who may contribute towards such a study the desirability of using a precise and accepted terminology. The confusion of terms introduced by some recent writers (who unfortunately speak as men having authority and not as the scribblers) is hard to explain or to excuse, considering how large is the choice of valid terms.*

The skeletal constituents of the lantern, in order beginning at the oral centre, are: — Five interradial Teeth each ending in an aboral plume (sometimes called *matrix.*). Each tooth is borne by a Pyramid, a paired structure of which the right and left halves are known as Hemi-pyramids or *half-pyramids*, and sometimes as *jaws* (*Kiefer, mâchoire*), a term better avoided since it has also been applied by some writers to the whole pyramid and by others to the adoral portion of the hemi-pyramid. For each hemi-pyramid consists of an adoral and an adapical element. The ten adoral elements were described by J. T. KLEIN (1734, p. 42) as «ossicula falciformia . . . . ex quibus maxillae, vel, si mauis, dentes molares quinque duplicati componuntur», and in the next sentence he speaks of the «paria maxillarum». The term Maxilla, previously used by RONDELET (1554, De Piscibus, lib. XVIII, cap. 30) for the same structures, is highly appropriate and is here adopted; it corresponds to the *pièce maxillaire* of F. BERNARD (Paléontologie, 1893) and the *Kinnlade* of JOH. MÜLLER (1854). Between the maxillae «intra duo ossicula» says KLEIN (loc. cit.) «dens caninus, velut in alueolo latitat». Alveolus then, here as elsewhere in anatomy, means a cavity in which a tooth (or other object) is lodged. T. H. STEWART (1861) seems to have been the first to misapply this term to the maxillae themselves; but his example should not be followed. The maxillae are united, «arcte conjuncta» (KLEIN) by a Symphysis. The small aboral element of each hemi-pyramid is called the Epiphysis, a term apparently due to JOH. MÜLLER (1854), and adopted by T. H. STEWART and LOVÉN among others, while A. AGASSIZ (1874, Revision, p. 688) prefers *apophysis*. Each pyramid then consists of two maxillae and two epiphyses. The epiphyses may unite interradially to form the Arcus (*arch, Knochenbogen, arc-boutant*). Whereas the separate epiphyses of *Clypeaster* were observed by A. PARRA (Descripcion de diferentes piezas de historia natural, &c.) so early as 1787, the arcus of an Echinid was figured (Tab. XXXI, fig. *a* and *i*) and described (p. 42) by KLEIN (1734) as «quinque paria ossiculorum, sinubus maxillarum applicanda». This must have been overlooked by J. MÜLLER when he credited PARRA with the first complete account of the jaw-skeleton.

* For the literature briefly referred to in this section, see the bibliography in BRONN'S «Thierreich» II, Abth. 3, pp. 971—1001; 1901.

Radially placed between the epiphyses of adjacent pyramids are 5 pieces, «quinque trabeculae, paria maxillarum coniungentes», as KLEIN says. His term unfortunately has never been adopted; instead one has to choose from a long series of more or less inappropriate or cumbrous expressions. Of these the first is Rotula, applied by C. DES MOULINS (1835, p. 232 = 66 of reprint) to these elements in *Clypeaster*, where they resemble in shape the rotula of the human knee; he subsequently (p. 428 = 193 of reprint) compared with these the homologous elements in Echinoidea Regularia. VALENTIN (1841) proposed the inappropriate term *falx* (*faux, sickle*), being perhaps misled by KLEIN's phrase «ossicula falciformia» applied not to the trabeculae, but, quite happily, to the maxillae. The term *brace*, adopted by DUNCAN (1889) and GREGORY (1900), appears to have been first used by A. AGASSIZ (1874, Revision, p. 688) who, however, still spoke of «the rotulae of the Clypeastroids» (p. 689), including in that term the rotula proper and the adjacent epiphyses. If the term *brace* be intended to express the mechanical function of the ossicle,* it must be an adaptation from the technical builders' usage (MURRAY, Engl. Hist. Dict., sub vocem IV, 17). But being without adequate representatives in other languages, notably in Latin, it is in this respect inferior to its three predecessors. The same objection applies to the *Schaltstück* of H. v. MEYER (1849) and the more cumbrous *Zwischenkieferstück* of A. LANG (Lehrbuch, 1894). Any of the preceding terms may be used without confusion, but the same cannot be said of the phrase *radial pieces* employed by MACALISTER (Introd. Anim. Morph., 1876) or even of *Laternradien* used by J. MÜLLER (1854). The term Rotula is adopted here as having priority among those terms that have found acceptance; it was used by LOVÉN.

Remain to be considered «Reliqua ossicula quinque, vecti ferreo, qui ab vngulis vaccinis nomen habet (*Kuhfuss* [Anglicé: crowbar]) similia, inter trabeculas interposita». (KLEIN 1734). In this sentence «inter» appears to be a mistake for «supra». C. DES MOULINS (1835, p. 428 = 193 of reprint) described the pieces more correctly as «posées comme des anses de panier en dessus et parallèlement aux précédentes», but he gave no name. The first name was Compass given by VALENTIN (1841), used by MÜLLER (1854), A. AGASSIZ (1874), LOVÉN (1892), and others, and here adopted. The Germans, following H. v. MEYER (1849) often call them *Gabelstücke* or *Bügelstücke*; F. BERNARD (1893) adds *pièce en Y*, and *étrier*; MACALISTER (1876) prefers *manubria*. Any of these terms are free from ambiguity, but it is hard to understand why DUNCAN (1889) and LANG (1894) gave *rotula* as a synonym, or why STEWART (1861), followed by H. M. BERNARD in the translation of LANG (1896), employed the overworn word *radius*.

The terminology of the various regions of each element, though extensive and detailed, is not particularly confused. Here that introduced chiefly by VALENTIN (1841) and emended by LOVÉN (Echinologica, 1892) is followed in the main.

Jerusalemhegy (*a*).

(Plate IX, figs. 220—222.)

Adoral end of a tooth. Raiblian.

Grooved, 5·8 mm. long, 1·7 mm. greatest width; the sides of the groove slightly flattened so as to approach a V shape (fig. 221); no sign of striae. The area of attachment to the dental slide defined by a slight groove between it and the rounded back of the tooth (fig. 220).

* «Durch sie werden die Kiefer so weit aus einander gehalten, dass bei der Action der Zwischenkiefermuskeln der unter der Rotula durchgehende Ambulacralcanal nicht gedrückt werden kann.» J. MÜLLER.

Jerussálemhegy (*b*).

(Plate IX, figs. 223—225.)

The maxilla of a right hemi-pyramid. Raiblian.

The inter-pyramidal joint-face (fig. 223) is narrow, being 6·8 mm. long, and attaining a width of only 2·8 mm. at 4·3 mm. from the distal end. Its aboral margin slopes, if anything, outwards and downwards (not as usual in Cidaridae). The transverse ridges, which are almost parallel to it, have a slight S curve, directed downwards externally and upwards internally, but their general direction is at right angles to the long axis of the surface. There are 6 to the millimetre. The fossa arcualis is narrow, 0·8 mm. at base of supra-alveolar process, which is 2·5 mm. high.

The outer surface (fig. 224) is also narrow and with only a very slight convexity. Length, 9·0 mm.; greatest width, just below the foveola arcualis, 2·6 mm. The external margin is sharp, thickening below. The admedian outer plane is smooth and 0·9 mm. wide. Between these two lies the fovea magna externa, narrow and rather deeply indented below, but broadening out above and becoming divided by a very slight median convexity into two sulci, of which one lies alongside the margo externus proeminens, ending in the foveola arcualis, while the other dies away as the floor of the fovea magna merges into the outer admedian plane. The upper end of this plane is cut off obliquely by the almost straight boundary of the supra-alveolar process.

The symphysial face is very narrow, broadening slightly for a short distance above and for a longer distance below to about 0·25 mm. The length of the symphysis is 8·0 mm., the full height of the hemi-pyramid being exactly 9·0 mm. The union therefore is through 0·88 of the whole length, precisely as given by Lovén for *Cidaris papillata* (Echinologica, p. 52).

The internal face (fig. 225) shows a very narrow central canal. Lineae eminentes not strongly pronounced, surrounding a slightly concave dental slide, and ending in a very faint styloid process. Above this the dental sulcus continues, bounded by a slight ridge, which ends in the angle of the supra-alveolar process.

Jerussálemhegy (*c*).

A fragment from the adoral end of a left maxilla. Raiblian.

This is probably of the same species as *b*, from which it differs in the thicker symphysis, 0·4 mm. wide.

Jerussálemhegy (*d*).

(Plate IX. figs. 226—228.)

A right maxilla. Raiblian.

Interpyramidal joint-face (fig. 226) 6·3 mm. long, greatest width at aboral end 3·6 mm. Aboral margin slopes inwards and downwards (as usual in Cidaridae). The transverse ridges have a slightly greater downward slope with a simple curve, convex downwards; 6 or 7 to 1 mm. Fossa arcualis wide, being 1·7 mm. at base of supra-alveolar process, which is 2·3 mm. high.

Outer surface (fig. 227) narrow (not so much as *b*), convex. Length 8·3 mm.; greatest width, just below fovea arcualis, 2·8 mm. External outer margin thickened, especially towards the ends. Admedian outer plane smooth, about 0·9 mm. wide. Fovea magna externa narrow, more deeply excavate than in *b*, and without the convexity obvious in that specimen; the sulci consequently are not so well defined. The upper end of the outer admedian plane is cut off obliquely by the boundary of the supra-alveolar process, which forms a slight re-entrant angle.

Symphysial face very narrow, broadening below to 0·5 mm. at the widest point. Length of symphysis 7·7 mm., the full height of the hemi-pyramid being 8·3 mm. The union therefore is through 0·92 of the whole length.

The internal face (fig. 228) shows a rather wide central canal, coming to an end where the symphysis widens. Lineae eminentes strongly pronounced. The dental slide appears to be marked in its lower half by three slight furrows. As these die out above, it appears convex rather than concave. Styloid process rounded but clear. Above it the sulcus and ridge, as seen in *b*, are not clearly defined.

The differences observable in almost every detail show that this cannot belong to the same species as *b*.

Jerussálemhegy (*e*).

A left maxilla with adoral end broken off. Raiblian.

Interpyramidal joint-face narrow (?), but, being broken and worn on the oesophageal border, its greatest width cannot be given. For the same reason the slope of the aboral margin cannot be distinguished. The transverse ridges slope rather sharply downwards and inwards, with a slight curve, convex downwards, in their outer half; 6 or 7 to 1·0 mm. Fossa arcualis apparently somewhat weathered; at least 1·2 mm. wide at base of supra-alveolar process, which is 2·7 mm. high.

Outer surface resembles that of *d*, but is not quite so convex, and external margin not quite so thick.

Symphysial face very narrow, broadening below.

Internal face as in *d*, except that the dental slide appears simply concave below, not furrowed.

Probably this specimen belongs to the same species, though not to the same individual, as *d*.

Vesspréna-Jutas Ry., Cutting I. (*a*)

(Plate IX, figs. 229—231.)

A left maxilla, from bed *e*. Raiblian.

Interpyramidal joint-face (fig 229) 7·2 mm. high, 3·3 wide at widest part, where, however, it appears to have lost the oesophageal margin. The aboral margin, which for the same reason is incomplete, seems to have sloped downwards and outwards. The transverse ridges are too much worn for description. The fossa arcualis seems to have been narrow, while the supra-alveolar process rises 2·7 mm. above it.

The outer surface (fig. 230) is narrow, with slight convexity. Length 9·6 mm.; greatest width 2·5 mm. External margin sharp. The admedian outer plane is smooth and attains a width of 1·2 mm. in its upper third, but becomes thinner near the lower end of the fovea magna externa, which is narrow and deeply indented. The upper end of the admedian plane is obliquely cut off by the boundary of the supra-alveolar process, which is slightly concave.

The symphysial face appears to have been narrow, widening below. Its length is 9·0 mm., i. e. 0·93 of the whole length, which, however, is probably not quite complete.

The internal face is too much worn for description, but the lineae eminentes can never have been very prominent.

Vessprém-Jutas Ry., Cutting I. (*b*)

(Plate IX, figs. 232—234.)

A right alveolus from bed *e*. Raiblian.

Interpyramidal joint-face narrow, (fig. 232) but margins are broken. Slope of aboral margin uncertain. Transverse ridges at right angles to the long axis of the joint-face, and almost straight, with a very faint S curve, bending downwards externally and upwards internally; 6 go to 1·0 mm.

Outer surface (fig. 233) narrow, with fairly well marked convexity. Too imperfect for accurate measurement. External margin thick. Admedian outer plane smooth, narrower below. Fovea magna deeply excavate.

Symphysial face 0·35 mm. wide, tapering slightly below.

Internal face (fig. 234): narrow central canal. Well marked lineae eminentes. Dental slide concave, the concavity being mainly in its outer half. Styloid process apparently continued as a ridge up the supra-alveolar process.

On the whole this specimen appears to belong to the same species as Jeruzsálemhegy *b*.

Vessprém-Jutas Ry., Cutting I. (*c*, *d*, *e*).

(Plate IX, figs. 235—237)

Three maxillae, all of the same form. Raiblian.

(*c*) A large right one (figs. 235—237).

(*d*) A medium sized left one.

(*e*) A small right one, obscured by tenacious matrix.

The following description is based upon *c* and *d*, the measurements being from *c*.

Interpyramidal joint-face (fig. 235) moderately wide. Length 10 mm.; actual width 4·3 mm., but since the oesophageal border is broken, it was probably a little more, perhaps about 5·0 mm. The face is irregularly curved, rising towards the adoral end of the maxilla, which projects beyond the joint-face. The adoral margin slopes inwards and downwards. The transverse ridges slope more strongly in the same direction and have also a curve with downward convexity; they are very faint, especially in the aboral third of the joint-face. About $5^1/_2$ go to 1 mm. The fossa arcualis is moderately wide, 2·5 mm. at the base of the supra-alveolar process, which is 3·9 mm. high.

The outer surface (fig. 236) is almost flat along the admedian plane, but convex along the external border. Thus it has, like the interpyramidal joint-face, an irregular twisted appearance. Length 14·1 mm., greatest width 4·4 mm. External margin rather broken, apparently rather sharp in its middle region, but thickening slightly above and considerably below, where it merges in a flattened area continuous with the admedian plane and bending round on to the interpyramidal face. The admedian outer plane is smooth, not clearly defined, but about 1·4 mm. wide. It slopes gently into the fovea magna externa, which is not deeply excavate. The fovea is not very narrow below; above it is divided by a slight median convexity into two sulci (as in Jeruzsálemhegy *b*). At the upper end the floor of the fovea merges into the admedian plane, and the two are truncated by the slightly sloping boundary of the supra-alveolar process.

The symphysial face is about 0·4 mm. wide, broadening to 0·95 mm. below; where it joins the dental slide. Its length is 13·3 mm. or 0·94 of the whole length.

Internal face (fig. 237): central canal wide, but stops where the symphysial face expands. Of the lineae eminentes, that adjoining the canal is the more pronounced. The dental slide is markedly concave. The styloid process, though distinct, is continued upwards as a ridge in line with the admedian border of the slide, thus cutting obliquely across the dental sulcus. The sulcus is bounded by an elevation or terrace, running up in the direction of the highest point of the supra-alveolar process.

Obviously these alveoli belong to quite a different species from those represented by the other specimens.

Vesaprém, Giricses Domb. (*a* & *b*).

(Plate IX, figs. 238—240)

Two distal portions of pyramids, the maxillae being still united. Of these *b* is the more complete, since in *a* most of the ala of the left maxilla is broken away; but *a* (figs. 238—240) is in other respects better preserved. Muschelkalk, Lower stratified Limestone.

Interpyramidal joint-face (figs. 238—240) rather narrow, 5·5 mm. high; 1·8 mm. or more wide. Aboral margin slopes very slightly inwards and downwards. Transverse ridges have a general direction parallel to the margin, with a faint S curve, directed downwards externally and upwards internally. They are 8 or 9 to 1 mm. The fossa arcualis is not very distinct, and the supra-alveolar process not well preserved.

The outer surface (fig. 239) is very slightly convex. Length 6·2 mm.; but this is not complete. Greatest width (of hemi-pyramid) 1·6 mm. External margin thick. Admedian outer plane smooth, about 0·4 mm. wide; but it rounds gently into the fovea externa magna, which seems to taper off to a point below.

Symphysial face not seen, probably extends almost the full length of the pyramid.

Internal face not seen. The inner aspect is shown in fig. 240.

Cserhát (Leitnerhof) (*a* & *b*).

(Plate IX., figs. 241—244.)

Two rotulae. Cassian.

a is the smaller and better preserved. (Figs. 241, 242).

b, which is about twice as large as *a*, has lost one end. (Figs. 243, 244).

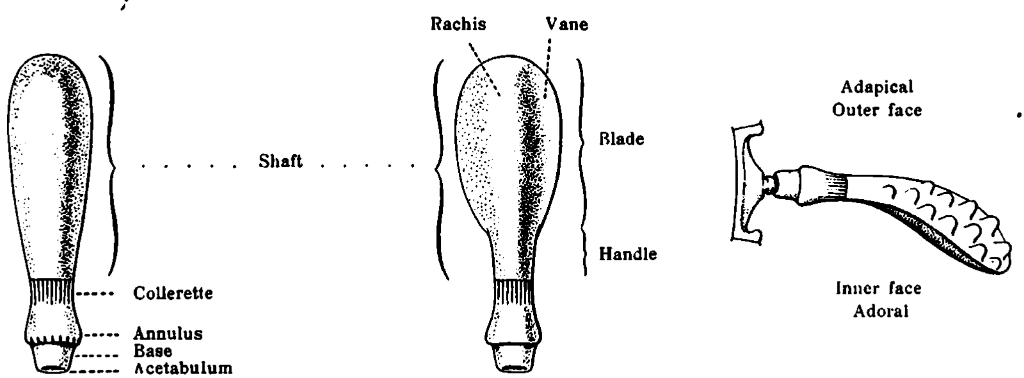
a is 3·8 mm. long, 1·8 at widest part. Its under surface (fig. 241) appears simpler than that of *Cidaris papillata* as figured by LOVÉN (Echinologica 1892, fig. 44), especially as it is not easy to distinguish the interior and exterior foveae. There is, however, an obvious eminence about the middle of each side, doubtless for the attachment of the musculi rotulae exteriores. There is a distinct median ridge. The upper surface (fig. 243) is gently rounded.

b is broken at the exterior or condylar end. It is 6·8 mm. long and 2·9 mm. at its widest part. The under surface (fig. 243), though devoid of the median ridge seen in *a*, appears to show both the foveae, although the exterior one is rendered indistinct by the above-mentioned fracture. It also shows an eminence for the musculi rotulae exteriores. The rotula is somewhat curved in the direction of its length, the concavity of the curve being uppermost. The upper surface (fig. 244) is rounded, and the excavation for the inner end of the compass is more marked than in *a*.

Obviously *a* and *b* are of distinct species.

The Radioles.

Terminology. — The terms employed are shown by the annexed diagrams.



Text-fig. 11. Diagrams showing terminology of Primary Radioles.

The term radiolus (Anglicé: *radiole*) was proposed by DESOR, and its English use has been sanctioned by P. Martin DUNCAN, W. P. SLADEN, and J. W. GREGORY. Shaft is the equivalent of the French *tige*, and the German *Stiel* oder *Körper*. The shaft is sometimes divisible into handle and blade, sometimes into rachis and vanes. Collerette equals the German *Stachelhals*. Annulus corresponds to the French *anneau*, the German *Ring*. Base is called by French writers *bouton* ou *tête*, by German writers *Stachelkopf*. Acetabulum was used by SLADEN in EASTMAN'S translation of ZITTEL'S Grundzüge

Most English writers have used *condyle,* which properly indicates a convexly rounded articular surface, and is therefore quite inapplicable. The French and German equivalents are *facette articulaire* and *Gelenkfläche.*

Variation and Specific characters in the Radioles. — Some of the radioles from these Triassic beds are so distinct in form or ornament that there is no great harm in assigning them to distinct species. Others, however, seem to have so wide a range of variation that there has been constant disagreement as to the limits of the species. Koechlin-Schlumberger (1855) has probably gone furthest in reducing the number of species erected by previous authors, and if it were possible to follow his lead without question, the work of determination would be greatly simplified. But there is much common sense in Broili's position (1904) that, since the various forms have been described, and can readily be recognised in most cases, therefore it is as well to denote them by the names generally adopted. A more rational basis, however, is desirable, and as a help towards its attainment it will be well to consider the kinds of variation that are to be expected in these radioles.

Limiting the discussion to primary radioles, one notices in an individual echinoid that there is not merely slight variation between radioles of the same rank, but a definite gradation of form according to the position of the radiole on the test. In some of the Cidaridae, notably *Goniocidaris clypeata* Doed., this is conspicuous, and there can be no doubt of its occurence in many of these Triassic echinoids. The abundant material of *Anaulocidaris testudo* has permitted the reconstruction of the entire series of radioles, thus confirming opinions previously expressed concerning the rare specimens of *A, Buchi.* In other Triassic species the variation appears to have been of the same character, which is in the main as follows. The radioles of the adoral surface are relatively small, and in shape approach a simple and probably primitive type. They may be cylindrical, slightly club-shaped, or slightly spatulate. Doederlein has also remarked on their deficiency of ornament. Probably it would nearly always be impossible to distinguish between allied species by means of their adoral radioles. The radioles on the periphery are relatively elongate and distinctly bilateral, having the adoral surface different from the adapical and usually with less pronounced ornament; the radiole is frequently bent downwards, so that the acetabulum, besides being widened transversely, is not at right angles to the axis of the shaft. The downward bending permits one to describe the adoral surface as «inner«, and the adapical surface as «outer». These peripheral or ambital radioles appear to be the ones that show most clearly the characters of the species. In the circumapical, or more briefly «apical», radioles those characters are slightly obscured by a further modification: the radiole resumes a position at right angles to the test, and becomes relatively shorter; frequently it expands distally, sometimes so much as to assume a mushroom shape, and may develop pronounced pustules or spinules. Whereas the ambital radioles are probably used in locomotion or for anchoring the animal, these expanded apical radioles probably serve as a protection to the whole animal and especially to the organs of the apical system. Remarkable examples of their modification are known from recent seas, such, for instance, as those figured by Doederlein (Japanischen Seeigel, pls. VI, VII), but that distinguished authority now proves incorrect in his statement (op. cit. p. 34) that these broadened ends first occur in the Chalk, for scarcely less remarkable are some of the Triassic radioles, whether from St. Cassian or Bakony. Here also are to be seen flattened spinules and collar-like expansions similar to, if not so pronounced as, those which, according to DOEDERLEIN, are found only in recent species. In extreme cases it is difficult, perhaps impossible, to distinguish between the apical radioles of allied species, while, on the other hand, the difference between an actinal and an apical radiole is so great that, in the case of isolated fossils, prolonged study of a large series of specimens is needed before one can recognise that they belong to the same species.

Another kind of variation is due to age. The peculiarities of the classes of radioles just described are far less marked in youth, and the radioles of allied species are then not so distinct. Transverse sections sometimes enable one to trace in a single radiole the gradual assumption of the adult features.

The Triassic echinoids doubtless displayed those differences between individuals with which zoologists are familiar in their living descendants. The limits of such variation within a given species can only be determined by a large series of measurements of radioles similar in position on the test and in age. Such evidence is not afforded by the material at our disposal, and in any estimate the chances of error are numerous.

Finally, in a comparison of radioles from various localities, it is necessary to enquire if they present such consistent differences as might be due to a change of environment acting on the whole assemblage at any one place. Here it is hard to distinguish the respective influences of place and time: contemporaneous faunas may exist under very different conditions, and may diverge into local races or species; or similar difference may be produced in the same area by the change of conditions, resulting in mutations or fresh species. Whether the variant forms represent races or mutations must be decided upon further evidence of a nature familiar to geologists. Whether any particular variant is to be regarded as an independent species, or merely as a local race or a mutation, is a question that can only be answered in an arbitrary manner according to the personal opinions of the describer, at least until zoologists are more agreed as to the amount of divergence that should constitute a specific distinction. There is however a simpler question, namely: Should these variants receive independent names? For the same reasons as have already been expressed concerning crinoid columnals, I advocate the giving of distinct names in all cases where a distinct and constant difference can be detected and formulated. The describer may think himself able to distinguish individuals from different localities, and may have the firmest conviction that those individuals represent distinct species or subspecies; but until he is able to formulate the differences in such a way that his colleagues can share or, at least, understand his conviction, he has not acquired the right to burden them with a new name. Consider, for instance, the radioles from St. Cassian, from the Seiser Alp, and from Bakony. In some cases one can say that the same species appears in all three localities; but in other cases, though there is a resemblance, yet there are also constant differences, which may be minute but which can be expressed in words. *Anaulocidaris testudo*, for example, might be referred by many systematists to *A. Buchi*; but differences, capable of description and measurement, have induced me to denote the former by an independent name. Here, however, an objection may be raised. Let it be assumed, for the sake of argument, that a few specimens of *A. testudo* are absolutely indistinguishable from a few of *A. Buchi*. This, say the objectors, is enough to show the invalidity of *A. testudo*. I do not agree. A better method is to compare the whole assemblage of *A. testudo* with that of *A. Buchi*. Setting aside the facts, above alluded to, that young radioles, or radioles from the actinal surface, may be similar in distinct species, it is admitted that the limits of variation in one species may encroach on the limits of another species. But two circles are not identical because their circumferences cut one another. If the variations of *A. testudo* and *A. Buchi* be represented graphically, the curves of the two species will be distinct. So it is with other species. Such assemblages indicate differences of time or environment, and to call them by the same name is to predicate an identity that does not exist.

A similar argument applies to assemblages occurring at the same time and place, but generally distinct in form. *Cidaris alata* and *C. dorsata*, as they occur at St. Cassian, are excellent instances. Normal examples are perfectly distinct, and yet there occur radioles about which no two authors are agreed. But if a large number of radioles be compared, it is seen that such intermediate forms are comparatively rare, and that the graphic representation of the whole material results in a markedly double curve.

The consideration of all these modes of variation therefore justifies the retention of many of the old divisions and names, not merely on the ground of practical convenience, but because the concepts actually are distinct. Where I have merged two of the old species, it has been because examination of the material, and especially of the type-specimens, has failed to reveal characters capable of verbal or numerical expression.

It has been the custom to refer nearly all Triassic radioles to *Cidaris*. Now that the genus *Cidaris* has been split up, this course is inadmissible. Whatever *Cidaris* s. str. may be — a question not yet satisfactorily settled by zoologists — it certainly is not known to occur in the Trias. Further than this, many of the radioles do not even appear to belong to Cidaridae. Except in the case of *Anaulocidaris*, there are no good grounds for referring any particular radiole from Bakony to one genus more than another. It therefore seems safest to use the word *Radiolus* in place of any accepted generic name, just as, in the case of columnals, one is occasionally driven to the non-committal word *Entrochus*. In referring to species previously described, one may of course use, without prejudice, the name under which each is best known.

Anaulocidaris.

1879. *Anaulocidaris* K. A. Zittel, Handb. d. Palaeont., Palaeozool., I, p. 486.

The genotype is *A. Buchi* (Münst.), concerning which the literature is as follows:

1829. *Cidarites Buchii* Münster in Goldfuss, Petref. German. I, p. 121, pl. XL, f. 5 *a*, *b*.
1834. » » Münster, Neues Jahrb. f. Min., 1834, p. 2 and p 8.
1841. *Cidaris Buchii* Münster, Beitr. z. Petrefactenk. IV, p. 43, pl. III, f. 11.
1841. » *remifera* Münster, op. cit. p. 43, pl. III, f. 12.
1852. » *Buchii* Münst., F. A. Quenstedt, Handb. d. Petrefactenk., p. 579, pl. XLIX, f. 10.
1855. » » Münst., E. Desor, Synops. Ech. foss., p. 20, pl. II, f. 8.
1855. » *remifera* Münst., ? = *C. Buchii* var., E. Desor, op. cit. p. 20, pl. II, f. 11.
1865. » *Buchii* Münst., G. C. Laube, Denkschr. Akad. Wiss. Wien, Math.-Naturw. Cl. XXIV, Abth. 2, p. 288, pl. X, f. 2 (includes *C. remifera*, as is the case in all subsequent authors).

1875. *Cidaris Buchii* MÜNST., F. A. QUENSTEDT, Petrefactenk. Deutschlands, III, p. 200, pl. LXVIII, f. 99.
1879. *Anaulocidaris Buchii* (MÜNST.), K. A. ZITTEL, Handb. d. Palaeont., Palaeozool., I, p. 486, f. 344.
1884. *Cidaris Buchi* MÜNST., K. A. ZITTEL, Verh. geol. Reichsanst. Wien, 1884, p. 149.
1884. » » MÜNST., K. A. ZITTEL, Neues Jahrb. f. Min., 1884, II, p. 132.
1884. » » MÜNST., E. W. BENECKE, tom. cit., pp. 132—134, ff. 1, 2.
1886. » » MÜNST., L. DOEDERLEIN, Neues Jahrb. f. Min., 1886, I, pp. 192—194.
1889. » *Buchii* MÜNST., S. v. WÖHRMANN, Jahrb. geol. Reichsanst. Wien, XXXIX, p. 194, pl. V, f. 15.
1900. *Cidaris Buchii* MÜNST., E. HESSE, Neues Jahrb. f. Min., Beil. Bd. XIII, p. 230.
1900. » *Buchi* MÜNST., K. A. v. ZITTEL, Sitz.-Ber. Akad. München, 1899) p. 350.
1900. *Anaulocidaris Buchi* (MÜNST.), J. LAMBERT, Bull. Soc. Sci. Yonne, LIII, p. 39 and p. 44.
1900. *Cidaris Buchi* MÜNST., F. BROILI, Centralbl. f. Min., 1900, p. 369.
1904. » » MÜNST., F. BROILI, Palaeontographica, L, p. 156, pl. XVII, ff. 45—48.

Diagnosis of the genus. — See p. 94.

The history of the genus may be briefly related.

Under the names *Cidaris* (seu *Cidarites*) *Buchii* and *C. remifera*, MÜNSTER (1829, 1834, 1841) described and figured radioles of the respective shapes here designated «spatuliform» and «remiform», both from the Cassian beds. The type-specimen of *C. remifera* (Pl. X, figs. 248, 249) and the heautotype of *C. Buchi* (Pl. X, figs. 246, 247) are preserved in the Palaeontological Museum at Munich, where I have examined them; their outlines are given in text-figures 27 and 37 (pp. 155 & 158). The holotype of *C. Buchi* is no longer to be found.

The gradual discovery of intermediate shapes led DESOR (1855) tentatively, and LAUBE (1865) definitely, to merge the two forms in a single species *C. Buchi*, a course followed by all subsequent authors. In 1879 ZITTEL described and figured some remains which he regarded as unituberculate interambulacrals, probably supporting the spatuliform and remiform radioles of *C. Buchi*. The hexagonal or irregular outline and bevelled margins of these plates led ZITTEL to place the species in the Archaeocidaridae, as the genotype of a new genus *Anaulocidaris*, the name being due to the absence of a scrobicule. It will here be noticed that this description agrees closely with that of the interambulacrals from Jeruzsálemhegy, described and referred to this genus on p. 95. There is, however, an important difference between the two sets of structures. Our interambulacrals have each an obvious mamelonate tubercle, whereas the fossils figured by ZITTEL would, if complete, have shown an acetabular cavity. The latter are in fact radioles of the shape here called «paletiform», and the recognition of this by ZITTEL (1884) was due to the discovery of intermediate «trulliform» radioles, some of which were excellently described and figured by BENECKE (1884). The genus *Anaulocidaris* was dropped, since mere modification of the radioles did not appear sufficient warrant for it; and so it has been left by all writers of importance except LAMBERT (1900), whose retention of it in the Perischoechinoidea is probably due to an oversight. The discovery of the undoubted interambulacrals has now led to the resuscitation of the genus, not, however, as an Archaeocidarid, but as a Cidarid, although, oddly enough, some of the peculiar characters of these plates did at first suggest a closer relationship to Archaeocidaridae.

The list of references to *Anaulocidaris Buchi* given above, is not intended as a synonymy. Though the radioles from the Cassian beds all belong to the same species, it is doubtful whether one should not distinguish those from the *Pachycardia* tuff of the Seiser Alp (Zittel, 1900, Broili, 1900, 1904); while those from the *Cardita* beds of Raiblian age (Wöhrmann, 1889) are not *C. Buchi,* but are possibly *C. testudo.* To these questions we shall recur.

Anaulocidaris testudo n. sp.

(Interambulacrals, Pl. VII, figs. 164—187. Radioles, Pl. X, figs. 256—272.)

Diagnosis. — An *Anaulocidaris* with relatively thin radioles: Radioli remiformes slightly curved downwards and not concave on inner face (length not known to reach 20 mm.); Radioli spatuliformes with handle bent at an angle to the blade, concavity of inner face rarely exceeding ·125 of thickness of blade, no distinct ridges (length not known to exceed 18·3 mm.); Radioli trulliformes with width usually exceeding twice the length, ridges from handle to distal angles slight or absent, outline of blade six-sided with sinuous distal margin and distinctly bevelled proximal margin, striae passing on to outer face cross one another at right angles; Radioli paletiformes with straight sides, bevelled on outer face, which is flat, thin blades, ridges of inner face faint or absent.

Material. — The interambulacrals are mentioned on p. 95.

The radioles number 473, distributed according to their forms and their localities as follows:

	Remi-form	Spatuli-form	Trulli-form	Paleti-form	Totals
Jeruzsálemhegy	58	57	100	23	238
Veszprém-Jutas Ry., Cutting I	31	64	85	18	198
» » » » » bed e. .	9	6	5	1	21
» » » » IV, beds a-b	1	3	8	1	13
» » Quarry near Cutting I .	0	1	1	1	3
Totals. . .	99	131	199	44	473

From among these specimens it is convenient to select as holotype one of the spatuliform radioles, comparable with the holotype of *Cidarites Buchi* Münst., and to take this from the locality in which the species is most abundant, namely Jeruzsálemhegy. As conforming with these conditions I fix on the original of Pl. X. figs 262—264.

Description of the Radioles. — Our knowledge of *Anaulocidaris* has grown up piece-meal, and no complete account of the radioles of the genotype has ever been published. The total number of specimens of *A. Buchi* preserved in the Museums of Munich, Vienna, Tübingen, and London, which, with the exception of some at Strassburg, include all the specimens hitherto mentioned in scientific literature, does not come near the number of specimens of *A. testudo* from either of the chief Bakony localities. Consequently it seems advisable to base on this abundant material a detailed description of the radioles of *A. testudo.* Except in those minor characters which will subsequently be indicated, this description will apply also to *A. Buchi,* and will enable us to reconstitute the whole aspect of this remarkable genus.

The following description is based on the specimens from Jeruzsálemhegy, which are the more numerous, and, on the whole, better preserved. But what is said applies equally to the rest.

Although a large number of radioles collected at random presents a continuous series of varying forms, uniting without a break the vastly different extremes of the series, still there are four main shapes into which the radioles can easily be sorted. These are, beginning with the adoral radioles, which are the least modified, and passing upwards:

1. Radioli remiformes, corresponding to the *Cidaris remifera* of Münster, narrow, slightly curved, with the handle in the same curve as the blade.

2. Radioli spatuliformes, corresponding to the *Cidaris Buchi* of Münster; the blade is subcircular and forms an obtuse angle with the handle.

3. Radioli trulliformes, corresponding to the shape figured by Benecke (1884), trowel-shaped, the blade hexagonal, wider than long, forms an angle of 60°—70° with the handle, which is marginal.

4. Radioli paletiformes, corresponding to the supposed *Anaulocidaris* interambulacrals of Zittel (1879), shaped like a plasterer's palette, blade hexagonal or pentagonal, not much or not at all wider than long, nearly or quite at right angles to the handle, which is removed from the margin and may even attain a subcentral position.

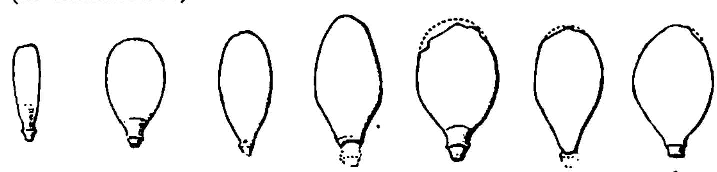
These forms, as manifested in *A. testudo*, will now be more minutely described.

1. Radioli remiformes.

(Pl X, figs. 256—261.)

From among the 58 specimens of this form found at Jeruzsálemhegy, 7 are selected for measurement (in millimetres).

Text-fig. 12.



	a	b	c	e	f	g	h
Length	12·5	13·9	15·7	19·1 ?	17·8	17·0 ?	17·3
Greatest width	3·5	7·5	6·5	8·5	10·5	8·8	10·5
Distance of greatest width from distal end	3·4	5·5	6·7	8·3	8·2	7·3	7·8
Thickness at same level	1·3	1·75	1·3	2·0	2·1	2·0	1·8
Greatest thickness	1·5	2·1	1·3	2·4	2·3	2·3	2·25
Distance of same from distal end	6·2	8·1	6·7	11·5	12·7	11·4	11·3
Least width at collerette	1·45	2·0	—	—	—	—	—
Thickness at same place	1·1	1·4	—	—	—	—	—
Width at annulus	2·1	2·0	1·8	—	3·0	—	2·8
Thickness at annulus	1·7	1·7	1·1	—	2·2	—	2·0
Distance of annulus from acetabulum	1·3	1·2	—	—	—	—	—
Width at acetabulum	0·75	0·8	—	—	—	—	—
Thickness at acetabulum	0·5	0·7	—	—	—	—	—

In comparing these measurements of thickness with those in the spatuliform and trulliform radioles, it should be remembered that in the remiform radioles the greatest thickness is theoretically in the sagittal plane, whereas in the others there is sometimes a median concavity making the radiole thinner in this plane than on either side of it.

Specimen *a* is the smallest and specimen *f* about the largest of the complete radioles that fall within the definition of «remiform» given above. Specimens *a* and *b* are represented on Plate X. (figs. 256—261), specimens *e*—*h* in the accompanying outline figures. It is easily seen from both measurements and figures that, whereas the thickness increases approximately in proportion to the length, the width increases much more rapidly. Thus if length be 100, then in *a* thickness is 12 and width 28, while in *f* thickness is 12·9 and width 59. In this respect there is a gradual transition to the spatuliform radioles.

Returning to *a,* however, we note that it differs very little from the secondary radioles of most Cidarids or from the adoral radioles of many. These radioles are always those in which the peculiar characters of the species are least manifest, and are therefore, one supposes, the nearest to the primitive ancestral form. At the same time they must themselves be modified in consequence of their position. Thus this radiole, in addition to being compressed, has its axis slightly curved, so that one of the flattened sides is convex and the other is concave. The former, as will be seen, is the adapical or outer face; the latter is the adoral or inner. The terms right and left will be used as coinciding with the right and left of the observer, when the radiole has its outer face upwards and its base towards the observer. This radiole is not quite bilaterally symmetrical, but is a trifle longer on the left so that the distal margin slopes up towards that side; the plane of greatest thickness also appears to lie a little to the left of the sagittal plane. This asymmetry, however, does not appear to be a constant character of the more adoral remiform radioles.

The downward curvature of the radiole was associated with a downward bending at its attachment, and this has produced its effects on the structure of the base. Thus the collar, as it passes from the outer to the inner surface, slopes in a distal direction, and so presumably remained parallel to the surface of the test. Again, the acetabulum is not merely transversely elliptical, but its rim is excavate on both the adoral and adapical margins; on the adoral margin the rim appears thrown into a slight fold, as though it had been pushed back; on the adapical margin are traces of a similar fold, but the excavation of the rim passes through the fold to the groove limiting it; thus the outline of the acetabulum approaches a triangle. In the description of the interambulacral plates referred to this species, it has been explained that the articular surface of the mamelon slopes adorally. In so far as this slope affects the whole structure and keeps pace with the downward bending of the radiole, it is not easy to see why the acetabulum should assume a triangular shape. But if the depression of the radiole were more pronounced than the slope of the tubercle, the central ligament would press against the upper edge of the acetabulum and would prevent the accretion of stereom at that point. In larger remiform radioles the fold on the edges of the acetabulum appears as a swollen ring.

The whole surface of the radiole tends to be longitudinally striate. On the shaft, however, this ornament can scarcely be distinguished, except in so far as the minute structure of the stereom appears under favourable lighting; it is doubtful if it ever was more conspicuous in this specimen. On the base below the annulus it is slightly more visible. On the collerette it exists as distinct though fine striae, about 12 of which go to 1 mm.

The collerette extends 3 mm. beyond the annulus, and is bounded by a faint but definite ridge, beyond which is a very slight contraction of the body of the radiole. In addition to the change of ornament at this line, some specimens show a change of colour (much more marked in *A. Buchi*) probably due to the greater density of the base. Many shafts are broken off just here, while others are crushed just beyond the collerette ridge. This indicates the less solidity of the shaft, which may have contained actual cavities. In this connection it is to be noted that the extreme distal margin of this radiole thickens slightly, to about 0.5 mm., and is marked right along the distal border by a distinct though shallow groove, which is also visible in other specimens of about this size and shape.

Specimen *b* differs from *a* chiefly in being more curved. If the radiole be laid, with its inner face downwards, on a flat surface, the summit of the convex curve is at a height of 2.5 mm. above that surface. This is at the thickest part of the shaft, so that the concave curve of the other face is far less, and is at 0.4 mm. above the flat surface. This radiole is a little longer and wider on the left, but the asymmetry is not so marked as in *a*.

The slope of the annulus is as in *a*. The rim of the acetabulum is slightly swollen, then comes a slight swelling between the rim and the annulus, then a rising up to the annulus. The whole of the base to the distal edge of the collerette is of a darker brown than the shaft; on the inner face a wide crack follows the rim of the collerette. There is no distal groove.

Striation can be detected on the collerette, but elsewhere is only visible at the distal border of the adoral face; here are well-marked striae, or sulci, about 6 to 1·0 mm., but not quite equal in width. The adapical surface at this end shows traces of small pustules. Both these types of ornament are faintly reminiscent of the radioles known as *Cidaris alata* and allied forms. They are to be seen in some of the other remiform radioles. In some (e. g. *d*) the pustules appear as slight elevations between the striae, which latter gradually increase in size and length nearer the distal margin.

Specimen *c*, which is thinner than the others, partly because it is crushed, shows the striation very plainly over the whole adapical face and the distal half of the adoral face, but less plainly, in its proximal half. No collerette can be distinguished, but the striae start at the annulus and increase in width and intensity towards the widest part of the radiole, thence decreasing in width towards the distal margin, where they are 10 to 1·0 mm. At the distal border of the adapical face the ridges show slight irregularities, which, however, are not so definite as to form pustules. In the absence of a collerette, the crushing extends right up to the annulus.

The measurements and outlines of specimens *e*, *f*, *g*, and *h*, show the forms and sizes of the larger remiform radioles. The considerable variation in the development of the collerette is again exemplified by the fact that in two radioles of nearly equal length the height of the collerette above the annulus is 2·3 mm. in *f*, and from 1·5 to 1·9 mm. in *h*.

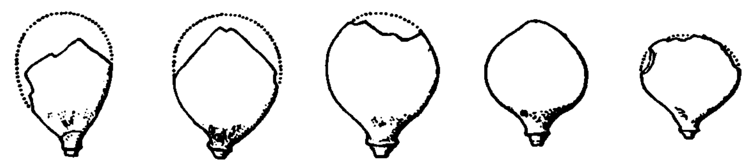
In a strongly striated shaft (*i*) about the size of *h*, the number of striae to 1·0 mm. is 8 on the adapical face and about 6 at the distal end of the adoral face.

2. Radioli spatuliformes.

(Pl. X, figs. 262—264.)

From among the 57 specimens of this form found at Jeruzsálemhegy, 19, lettered *a* - *s*, are selected for measurement and outline drawings. All these drawings represent the outer or adapical face.

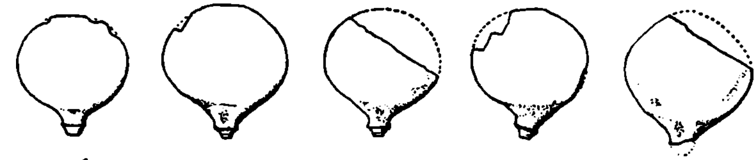
Text-fig. 13.



	a	*b*	*c*	*d*	*e*
Length	—	17·0	—	16·1	13·2
Greatest width	—	13·0	—	13·3	13·2
Distance of greatest width from distal end . . .	—	7·7	—	7·5	5·4
Thickness at same level*	—	1·7	—	1·8	1·5 & 2·0
Greatest thickness . . .	2·4	2·3	2·6	2·4	2·4
Distance of same from distal end	—	12·6	—	11·9	7·7
Least width at collerette	2·3	2·9	3·4	2·6	2·5
Thickness at same place	1·7	1·9	2·2	1·7	1·6
Width at annulus . . .	2·6	3·1	3·8	2·9	2·5
Thickness at annulus. .	2·0	2·3	2·6	2·1	1·8
Distance of annulus from acetabulum, on outer face	1·1	1·4	1·6	1·4	1·2
Distance of annulus from acetabulum, on inner face	1·9	1·7	2·0	1·9	1·6
Distance from annulus to rim of collerette, on outer face	2·4	1·1	?	1·0	?
Distance from annulus to rim of collerette, on inner face	1·5	?	?	1·9	0·6

* When two measurements are given, the first is the thickness in the median line, the second is the thickness over all.

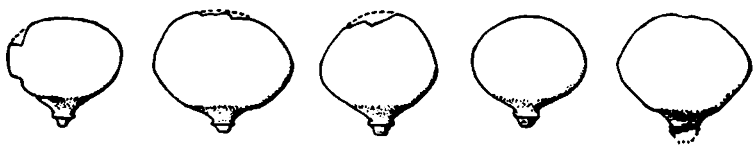
Text-fig. 14.



	f	*g*	*h*	*i*	*j*
Length	15·8	17·6	16·5 ?	17·2	18·3 ?
Greatest width	14·5	16·5	15·5 ?	15·2	16·3
Distance of greatest width from distal end	6·8	7·5	6·5 ?	7·2	8·3
Thickness at same level	1·5	1·6 & 2·0	1·4	1·6 & 1·8	1·5 & 1·7
Greatest thickness	2·5	2·7	2·4	2·7	2·6
Distance of same from distal end	12·8	12·5	12·5 ?	13·0	14·0 ?
Least width at collerette	2·7	3·0	2·6	—	—
Thickness at same place	1·9	1·7	1·7	—	—
Width at annulus	2·7	3·2	2·8	—	—
Thickness at annulus	2·2	1·8	2·2	—	—
Distance of annulus from acetabulum, on outer face	1·5	1·4	1·4	—	—
Distance of annulus from acetabulum, on inner face	1·7	1·5	2·0	—	—
Distance from annulus to rim of collerette, on outer face	0·8	0·9	1·0	—	—
Distance from annulus to rim of collerette, on inner face	1·0	1·3	1·0	—	—

i and *j* are not well preserved in the proximal region.

Text-fig. 15.



	k	*l*	*m*	*n*	*o*
Length	13·7	15·5	15·5	14·4	15·5 ?
Greatest width	14·7	17·6	15·1	15·1	17·5
Distance of greatest width from distal end	5·3	6·7	7·5	6·5	7·0
Thickness at same level	1·2 & 1·3	1·5	1·5 & 1·6	?	1·6 & 1·8
Greatest thickness	1·6	2·2	2·4	?	2·5
Distance of same from distal end	10·5	13·0	12·4	?	12·6
Least width at collerette	2·5	3·2	2·8	—	?
Thickness at same place	1·7	1·9	1·8	—	?
Width at annulus	2·6	3·3	3·1	3·2	?
Thickness at annulus	1·8	2·3	2·1	2·2	?
Distance of annulus from acetabulum, on outer face	1·0	1·5	1·3	1·5	?
Distance of annulus from acetabulum, on inner face	1·8	2·0	2·1	1·9	?
Distance from annulus to rim of collerette, on outer face	?	?	1·0	?	?
Distance from annulus to rim of collerette, on inner face	?	?	1·5	?	?

Text-fig. 16.

	p	*q*	*r*	*s*
Length	14·0?	11·5?	10·4	10·2
Greatest width	16·5?	15·0?	15·5	16·2
Distance of greatest width from distal end	?	?	4·2	4·7
Thickness at same level . .	1·5?	1·6	1·2 & 1·45	1·9 & 2·3
Greatest thickness	2·4	2·2	2·2	2·6
Distance of same from distal end .	?	?	8·2	8·4
Least width at collerette	2·8	2·8	2·8	2·7
Thickness at same place. . .	2·0	1·5	1·7	—
Width at annulus	3·1	3·0	3·0	—
Thickness at annulus	2·2	1·8	1·7	—
Distance of annulus from acetabulum, on outer face .	1·3	—	1·0	—
Distance of annulus from acetabulum, on inner face .	1·6	1·5	1·3	—
Distance from annulus to rim of collerette, on outer face .	?	—	?	—
Distance from annulus to rim of collerette, on inner face .	?	0·5	?	—

In this series we trace a gradual reduction of length resulting in a relative increase of width. The absolute increase in width is not so marked. In correlation with this, the line of greatest width moves absolutely nearer to the base, but at the same time is nearer the distal margin. The handle of the radiole no longer makes a gentle curve with the blade, but is bent at an angle to it in the region of greatest thickness, which angle gradually increases, thus diminishing the length of the radiole. The outline of the blade, from being somewhat racquet-shaped, gradually tends to a roughly hexagonal shape, wider than high, with the distal margin and the two distal sides fairly straight, but with the proximal margin, taken as coinciding with the line of greatest thickness, forming a curve, convex towards the base of the radiole, and merging into the proximal side of the hexagon.

The blade thins gradually to its free periphery, especially in the distal region; the proximal margins, being nearer the line of greatest thickness, are not so sharp as the distal ones. The outer or adapical surface of the blade has a slight convex curve. The inner surface of the blade is in some specimens slightly concave, as may be seen by examining the measurements of thickness in the line of greatest width. The concavity is only about 0·1 or 0·2 mm. ($=1/_8$ the whole thickness), very rarely more and usually less. In the wider and more hexagonal forms, this concavity of the inner and convexity of the outer surface passes into a new feature, namely a slight bevelling of the proximal sides of the hexagon on the outer surface, combined occasionally with a very slight bending of those edges on the inner surface. As may be learned more easily from the trulliform radioles, this bevelling of the edges indicates that the blades of the adjacent adapical radioles overlap these edges by their distal margins.

The collerette is often indistinctly separated from the proximal part of the shaft (or handle). In many specimens the striation is not clear on the blade, and, even when clear there, it is scarcely to be detected on the handle. Whereas in the remiform radioles and in the narrower spatuliformes the striae of the blade appear to converge to the handle, and to be continuous throughout, in the wider spatuliformes the striae on the wings of the blade are cut off at the margins and not continued on the handle. The number of striae to 1·0 mm. is 6 on the outer face of specimen *j*, and the same at the proximal end of the outer face in specimen *k*. In the distal region of the latter, the striae become mere granules. In *m* the striae on the collerette are distinct; those in the proximal region of the shaft are less distinct.

The annulus is distinct, and is curved distalwards in the median line on both inner and outer surfaces, but more so on the former, as indicated by the detailed measurements. The rim round the acetabulum is also well marked as a rule.

Except for the very slight concavity occasionally seen on the inner surface of the blade, there is no sign of ridges passing from the handle to the distal angles of the blade, such as characterise the similar form in *A. Buchi*.

Although the handle, as stated, forms an angle with the blade, the ridge at the apex of the angle is not raised. In other words there is no depression in the handle on the proximal side of the angle-ridge (Pl. X, fig. 264). It is this feature that may be taken to separate the spatuliform from the trulliform radioles. Another distinctive character is that in the spatuliformes the distal margin is not excavate as it is in the trulliformes. Of course there are specimens that cannot easily be assigned to one more than the other, but they are rare.

3. Radioli trulliformes.

(Pl. X, figs. 265—269.)

From among the 100 specimens of this form found at Jeruzsálemhegy, 19 lettered *a*—*s* are selected for measurement (in millimetres) and outline drawings. But in order that these measurements may be intelligible, it is convenient first to give the description of a single well-developed radiole, lettered *f*. The intermediate stages, as represented by *a* - *e*, lead one to regard this as modified from the spatuliform type by the greater bending of the handle towards the inner surface of the blade, resulting in the sharp delimitation of the latter. The handle, instead of being like that of an oar or a racquet, is now like the handle of a bricklayer's trowel, in that it springs from the back of the blade at a sharp angle, while the base proper again bends round so as to become more nearly parallel to the plane of the blade. At the same time the blade assumes a curved hexagonal outline and increases in width. These changes are gradual, but the clearly marked forms, such as *f*, are far more numerous than the intermediate ones. The description of *f* will now be given in detail (Pl. X, figs. 265, 266).

The shaft is here clearly divided into blade and handle, the latter being continuous with the base proper, which comprises collerette, annulus, and acetabulum. The blade is differentiated by a clearly defined margin into an inner and an outer face. These correspond in the main to the inner and outer faces of the remiform and spatuliform radioles, but are not strictly homologous therewith, since the outer face no longer passes down on to the handle, which is entirely transferred to the inner face. On the other hand, while the two faces of the handle can still be distinguished as adapical and adoral, those terms are no longer applicable to the two faces of the blade.

For descriptive purposes the distal margin of the blade may be termed North. Then, whether one be looking at the inner or outer face, the five other sides of the hexagon may be termed NE., SE., S., SW., and NW., respectively.

The outline of the blade forms a hexagon with curved sides, having an extreme width of 20·4 mm., and a N—S diameter in the median line (i. e. length) of 9·1 mm. The S. side measures 13·5 mm. from angle to angle; it is convexly curved with a very slight reëntrant curve towards the middle line of the handle. This line is not in the sagittal plane of the blade, but about 0·25 mm. nearer to the SSE. angle of the outer face.

From outer side. From inner side.

Text-fig. 17. *Anaulocidaris testudo*, trulliform radiole *f*.

The N. side from angle to angle measures 12·3 mm.; it has a concave curve corresponding to the convexity of the S. side, but more pronounced, and with a median elevation corresponding to the depression in the latter. Viewed from the outer face, the NE. and NW. sides are convexly curved, the NE. measuring about 5·1 mm., the NW. about 5·6 mm.; the SE. and SW. sides are concave, but the curve is less than in the NE. and NW. sides; the SE. side measures about 5·3 mm., the SW. side about 5·8 mm. Corresponding with the greater length of the western sides, the line joining the NNW. and SSW. angles (9·1 mm.) is greater than that joining the NNE. and SSE. angles (8·5 mm.). The asymmetry then consists in the slightly greater extent of the left side (W. as seen from the outer face). There does not, however, appear to be any difference in thickness, since the thickness measured along the lines joining NNE. to SSE., and NNW. to SSW. is 1·6 mm. for both sides. These lines of measurement are hereinafter designated as x—y (see text-fig. 19^a).

The outer face is slightly convex, with the following modificatios: 1. a slight sinking towards the distal margin in the space between the NNE. and NNW. angles; in other words the surface is most elevated along lines joining the middle of the S. side to those angles, and these elevations, scarcely perceptible to the eye, represent the ridges of *A. Buchi;* 2. a well-marked bevel along the SW. and SE. sides, with a maximum width of 0·9 mm. in the plane of the blade, and of 1·5 mm. in the plane of the bevel; 3. a slighter bevel, at a sharper angle, along the S. margin; this thins out as it approaches the central depression.

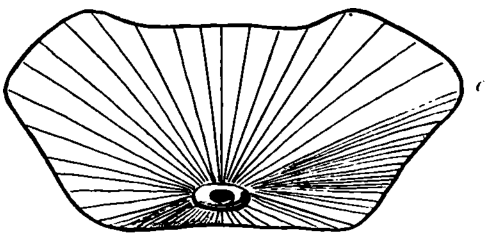
The inner face N. of the handle is gently concave, but the concavity is less regular than the convexity of the outer face. The main modifications are: 1. a well-marked bevel on the distal margin between the NNW. and NNE. angles; this follows the curve of that margin to some extent, but is narrower in the median line, where its width is 1·0 mm. in the plane of the blade, and 1·35 mm. in the plane of the bevel; 2. a less clearly marked bevel on the NE. and NW. sides, most marked towards the NNE. and NNW. angles; 3. a rising up to form the handle, steeply on the north side, but gradually on the E. and W. sides of it, thus forming a couple of broad ridges that pass towards the E. and W. corners; 4. on the S. side of the ridges, the surface slopes gently down to the margin, but immediately S. of the handle the slope is almost vertical to the blade and is slightly hollowed in a transverse sense thus producing two broad ridges running from the handle towards the SSW. and SSE. corners. The four ridges that run from the handle to the E. and W. and SSE. and SSW. corners must be distinguished from the two ridges that in *A. Buchi* run to the NNE. and NNW. corners. The former are homologous with the sides of the handle as seen in the spatuliform radioles; the latter, as we shall see later, have a different origin.

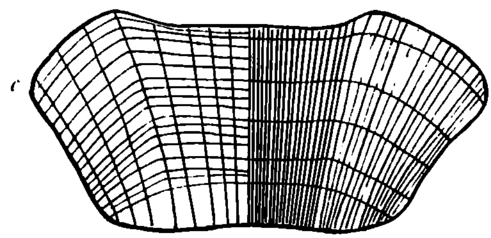
The base in this specimen is clearly distinguished from the cream-coloured shaft by a brown tint. The curves of the handle are continued over the collerette, which, however, is marked off from the handle by a sudden, clean-cut, but very slight descrease of diameter, the width being 3·6 mm. and the thickness 2·4 mm. Further, the striae on the collerette, though very fine, are more distinct. The collerette is not so easily distinguished from the annulus, but its height may be estimated as 0·6 mm. on the adapical side and 0·4 mm. on the adoral. Thus it is very short in proportion to the width of the base, and its distal magin is not quite parallel to the annulus. The course of this margin and of the annulus will be better understood after the acetabulum has been described.

The acetabulum is a hollow of transversely subelliptical outline, the ellipse being slightly flattened on the north or adoral side. The acetabular rim is well-marked and separated by a slight groove from the rest of the base. The external measurements of this rim are: width 1·5 mm.; thickness 1·2 mm. The rim does not all lie in one plane, but, as seen from the proximal end of the radiole, appears to sink on the N. and S. and to rise on the E. and W. This deflection is slight, and, if it be ignored for the moment, the plane of the acetabular rim may be described as sloping southwards at an angle of about 45° to the general plane of the blade. From the acetabular rim the base slopes, with a convex curve, to the annulus. On the north side, however, the slope is steeper than on the south; in other words the base is flattened on the north side.

The annulus is a rounded ridge, more clearly raised on the side of the acetabulum than on that of the collerette. It is deflected from the imaginary plane at 45° to the blade in the same way as the acetabular rim, but to a far greater extent. Thus the E. and W. sides rise up towards the proximal end of the radiole, while the N. or adapical side is depressed towards the blade. The shape can best be compared to the brim of a felt hat turned up on one side more than on the other.

We are now in a position to consider the complicated ornament of the shaft. This consists of fine striae and the ridges between them. On the inner face these are more clearly seen. Starting from the bottom of the handle, where it joins the collerette, they radiate to all the sides. Since the adapical side of the handle is morphologically part of the outer, and primitively adapical, face of the shaft, one is not surprised to se ethat the striae which go to the S. margin pass over it and then radiate from that margin over the outer face to the N., NE., and NW. margins; those at the sides are approximately parallel to the SE. and SW. margins. What does surprise one is that the striae which radiate from the handle over the inner face to the SE. and SW. margins do, in like manner, pass over those margins, and then continue over their bevels on the outer face in a direction parallel to the NE. and NW. margins, until they meet the striae passing from the S. margin to those margins. What happens next is not clearly shown in specimen *f*, for there, as in most, the striae are not distinct except near the margins. From a few other specimens, in various states of preservation, it appears that the striae parallel to the NE. and NW. margins continue across the radiating striae; or, rather, the structures merge in a regular manner and initiate a series of concentric ridges parallel to the NW., N., and NE. margins.





Text-fig. 18. *Anaulocidaris testudo.*

Diagrams of trulliform radiole, to show direction of lines of ornament. The lines are put in more closely between *a*, *b* and *c*, *d*, and the same lines may be traced from the inner face, over the edge to the outer face.

The passage of striae from the inner to the outer face over the SE. and SW. margins, as well as over the S. margin, appears to indicate that all those tracts of the inner face, to the S. of lines drawn from the acetabulum to the NNE. and NNW. corners, are morphologically part of the outer face. The broad ridges that were described above as passing from the handle to the E. and W. corners may thus be the obsolescent remains of the original margin of the remiform radiole. But, however it may have arisen, this passage of the striae has produced two strongly contrasted patterns on the two faces of the blade; and, since the striae arise out of the intimate structure of the stereom, it results that one face is built on a different plan from the other. This is not perhaps what one would naturally expect in so thin a blade, but it is rendered possible by the well-known structure of the Cidaroid radiole, with its ostracum or epistereom. In these blades the mesostereom is very thin, or even absent, towards the margins, but the epistereom of each face remains distinct from that of the other face, as may be seen in some broken specimens.

Having described specimen *f* as typical of the trulliform radioles, we may now proceed to the measurements of the 19 radioles selected to show the gradual modification within the limits ot this form. In the following figures the outer or adapical face is shown in *a, b, c;* in all the others the inner face only is represented.

The specimens have been arranged so as to illustrate the continuous series that connects the radioli spatuliformes with the paletiformes. The feature by which one is chiefly guided is the gradual bending of the handle, and its passage from the S. margin towards the centre of the blade, since this appears to be the feature most closely correlated with the position of the radiole on the test. With the specimens so arranged, it is seen that the blade first increases in width and in angularity until an acme of relative width is reached; then, without decrease in angularity, and in fact with increase in the straightness of the sides, it decreases in relative width, and this decrease is more rapid at the S. margin and less at the N. margin, with the result that the SW. and SE. sides increase in relative length. At the same time there is a decrease in absolute size.

Text-fig. 19.

	a	*b*	*c*	*d*
Length of blade in median line	8·7	10·0	9·2	9·1
Greatest length of radiole	10·8	12·1	11·3	11·4
Greatest width	15·5	18·2+	17·6	18·5
Distance of greatest width from distal end . .	4·2	5·4?	3·3	3·5
Length of N. side . .	9·2	12·7	10·0	10·5
Length of S. side . . .	9·5	11·5?	11·5	11·3
Median vertical thickness at equator	1·3	1·6	1·5	1·35
Greatest thickness along the line $x—y$ . .	1·1	1·7	1·6	1·3 & 1·4
Width at annulus . .	2·7	3·5	3·3	3·3
Thickness at annulus.	1·7	2·2	2·2	2·1

Specimen *a* is barely distinct from the spatuliformes; the acetabulum is about at right angles to the blade.

In *b* the distal margin is irregular and probably was broken in life.

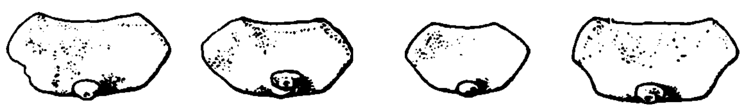
Text-fig. 20.

	e	*f*	*g*	*h*
Length of blade in median line	9·5	9·1	8·6?	6·8
Greatest length of radiole .	10·7	10·4	10·2	7·65
Greatest width	19·2	20·4	20·0	15·1
Distance of greatest width from distal end . . .	4·2	3·7	3·6	3·0
Length of N. side . .	12·5	12·3	11·5	11·0
Length of S. side	13·8	13·5	13·5	10·7
Median vertical thickness at equator.	1·5	1·3	1·5	1·0
Greatest thickness along the line $x—y$	1·6	1·6	1·7	1·0
Width at annulus . .	3·7	3·7	3·5	2·65
Thickness at annulus. .	2·3	2·6	2·1	1·75

Text-fig. 21.

	i	*j*	*k*	*l*
Length of blade in median line	8·7	9·1	8 7	9·5
Greatest length of radiole	9·0	10·5	9·5	10·9
Greatest width	19·7	20·3	22·3	20·7
Distance of greatest width from distal end	5·3	4·0	4·7	3·2
Length of N. side	14·0	12·0	13·0	12·5
Length of S. side	13·0	14·0	13·0	15·0
Median vertical thickness at equator	1·1	1·3	1·1	1·2
Greatest thickness along the line *x*—*y*	1·1	1·3 & 1·5	1·5	1·2 & 1·25
Width at annulus	3·7	3·5	4·0	4·1
Thickness at annulus	2·4	2·1	2·4	2·5

Text-fig. 22.



	m	*n*	*o*	*p*
Length of blade in median line	9·35	9·1	8·0	9·8
Greatest length of radiole	11·0	9·8	9·0	10·4
Greatest width	21·1	19·7	16·2	21·5
Distance of greatest width from distal end	3·7	3·6	3·7	4·5
Length of N. side	13·0	11·0	8·5	15·5
Length of S. side	14·25	12·0	10·0	14·2
Median vertical thickness at equator	1·35	1·4	—	1·5
Greatest thickness along the line *x*—*y*	1·4 & 1·75	1·5	1·4	1·5
Width at annulus	4·0	—	3·0	3·9
Thickness at annulus	2·5	—	2·0	2·7

In *n* the annulus is broken.

In *o* the surface is largely covered with matrix.

Text-fig. 23.

	q	r	s
Length of blade in median line .	9·0	5·0	5·75
Greatest length of radiole . .	9·25	5·2	5·8
Greatest width	19·2	12·8	11·45
Distance of greatest width from distal end	5·0	3·0	3·5
Length of N. side . .	13·5	9·0	8·0
Length of S side	10·5	7·75	7·4
Median vertical thickness at equator .	1·2	1·0	0·8
Greatest thickness along the line $x-y$	1·3	0·75 & 0·9	0·7
Width at annulus	3·25	2·2	2·1
Thickness at annulus	2·5	1·5	1·4

The outline of *r* is heptagonal; on its outer face striae pass towards the centre from S., SW., SE., and E. margins.

The outline of *s* is subheptagonal.

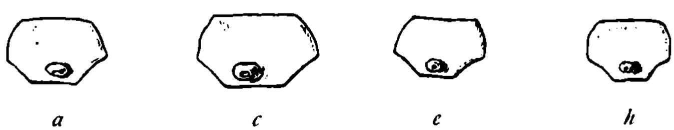
It is very difficult to draw any line between the radioli trulliformes and the paletiformes. There are two criteria that may be roughly employed. The trulliformes may include: first, all specimens in which the acetabulum remains visible when the radiole is placed on a horizontal plane, with its outer face uppermost, and viewed vertically from above; secondly, all specimens in which the width of the blade (E.—W.) is more than twice the length (N.—S.). These two characters, however, are not strictly correlated.

4. Radioli paletiformes.

(Pl. X, figs. 270—272.)

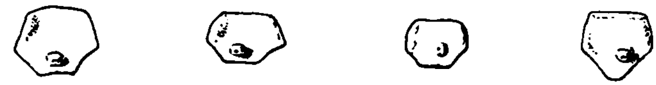
From among the 23 specimens of this form found at Jeruzsálemhegy and lettered *a*—*w*, 13 are selected for measurement (in millimetres) and outline drawings. All these figures show the inner face only.

Text-fig. 24.



	a	c	e	h
Length of blade in median line	8·2	9·2	7·4	7·5
Greatest width of blade . .	12·75	15·7	10·7	10·9
Length of N. side . . .	9·3	10·7	8·2	8·25
Length of S. side	5·5	7·1	4·5	4·2
Thickness at the centre of the blade	1·2 & 1·0	1·3 & 0.7	0·9	1·0
Greatest thickness along the line $x-y$	1·2	1·2	1·1	1·0
Width at annulus	2·8	3·0	2·3	1·9
Thickness at annulus . . .	2·1	2·8	1·9	1·5

Text-fig. 25.



	j	*l*	*m*	*o*
Length of blade in median line	8·5	6·4	5·9	8·7
Greatest width of blade . .	10·6	9·7	8·1	9·2
Length of N. side .	7·0	5·8	6·0	6·5
Length of S. side	3·7	3 3	3·3	1·25
Thickness at the centre of the blade	0·7	0·75	1·0	1·1
Greatest thickness along the line *x*—*y* . .	1·0	1·0	0·8	1·15
Width at annulus .	2·1	1·8	?	1·9
Thickness at annulus .	1·6	1·6	?	1·85

Text-fig. 26.

	p	*q*	*r*	*u*	*v*
Length of blade in median line	6·6	6·0	6·2	6·2	6·8
Greatest width of blade . .	7·6	6·3	6·7	6·4	7·3
Length of N. side . . .	4·3	3·5	4·6	3·6	5·0
Length of S. side	0	0	0	0	0
Thickness at the centre of the blade . .	1·1	1·0	1·0	0·8	0·9

In these five the annulus is not preserved well enough for measurement. With the elimination of the S. side the measurement *x*—*y* can no longer be given.

Of the 23 specimens, 15 have 6 sides, 7 have 5 sides, and one is just on the turn. The six-sided blades broadly resemble the trulliformes, but show an approach to the five-sided outline. They present the following combination of characters: the S. side is shorter than the N. side; the handle is removed from the margin of the blade, and is set either at right angles to the blade or so nearly at right angles that it cannot be seen from above when the radiole is laid on a horizontal plane with the outer face uppermost; thus the handle does not enter into the measurement of the greatest length of the radiole, as it does in the trulliformes, and the distance from the acetabulum to the distal margin is actually less than the length of the blade.

The change from the six-sided to the five-sided outline is due to the shortening and final disappearance of the S. side. The handle, which gradually moves nearer the centre, thus comes to lie about the middle of the line joining the SW. and SE. angles. It is not easy to orient all the five-sided blades, but in most cases the N., NE., and NW. sides are still distinguished by the bevel on the inner face, while there are still traces of the bevel on the outer surface of the SW. and SE. sides. The handle and base afford little help in orienting, since the handle becomes more concentrated and therefore more cylindrical, while the base, perhaps owing to the greater relative length and slenderness of the handle, is frequently broken off.

Having, however, oriented the blades according to the bevels, we see that they are much less symmetrical than in the other forms. Even in the six-sided blades of this form the handle is often conspicuously shifted to one side; in most of the specimens preserved that side happens to be the W. as seen from the under surface, but this I regard as accidental. In the five-sided forms, owing to the absence of the S. side, this shifting of the handle is correlated with a shortening of the SW. side when the handle is moved towards the W. and of the SE. side when it is moved towards the E. In these specimens the shifting appears to be indifferently to the E. or W.

The inner face of the six-sided blades is like that of the trulliformes, except for the greater narrowness of the handle and the flattening of the surface on the S. side of it. In the five-sided blades, however, the concavity between the handle and the NW. and NE. corners disappears, and the surface may become convex. The outer face, which is convex in the six-sided blades, becomes flatter in the five-sided ones, but never concave.

The striated ornament is not visible on any of the radioli paletiformes.

Comparison of *A. testudo* with *A. Buchi.*

Before discussing the relations of the various radioli to one another and to the test, it will be as well to consider such further information as can be obtained from *A. Buchi.* A good deal has been written about that species, but no connected account of all the forms of radiole has ever been given, nor have their relations been quite correctly understood. Thanks to the abundant material of *A. testudo,* it is now possible to imagine a correspondingly complete series of radioles for *A. Buchi,* and to place the various specimens scattered through several museums into their places in that series. Since most of the specimens are incomplete, outline figures are given, sometimes restored in a dotted line. Lines pointing to various regions of these figures indicate the exact levels at which certain of the measurements were taken. All measurements are given in millimetres.

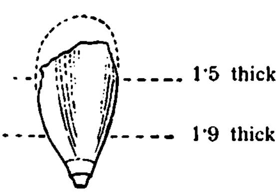
1. Radioli remiformes.

(Pl. X, figs. 248, 249.)

The specimens examined are the following:

(MM) In the Palaeontological Museum, Munich.

a)



Text-fig. 27.

Actual length .	. 18·7	
Estimated length .	. 22·5	(24·3 in Münster's reconstruction)
Greatest width : .	9·6	
Width of annulus. .	3·2	
Thickness of annulus	2·4	

Original of Münster (1841), pl. III, f. 12. The holotype of *Cidaris remifera*. The specimen is slightly crushed, so that the thickness was probably greater than the actual measurements. The appearance of a median depression is perhaps not wholly due to crushing. The thickness is here measured between the flat blades of sliding callipers, and the median depression is therefore not taken into account.

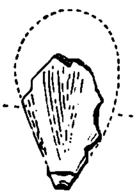
b)

Text-fig. 28.

Actual length	14·0
Greatest width	7·5
Width of annulus	2·8
Thickness of annulus	2·2
Thickness of blade over all	1·3
Thickness in median line	0·9

A smaller and less complete specimen of the same general form as *a*. Münster collection. Paratype of *C. remifera*. Note the slight median depression, partly due to crushing, but in the measurement this is compensated to some extent by a film of matrix.

c)



3·2 thick over all
3·0 thick in median line

Text-fig. 29.

Actual length	17·2
Estimated length	23·0
Actual width.	10·0
Estimated width	14·4
Width of annulus	3·7
Thickness of annulus	2·8

Registered «1894, XIII, 294». Labelled, «Mittlere Cassian Sch., Piccol Bach.» Is nearer to spatuliform than *a* or *b*, and shows the median depression more clearly.

(RAW) In the Geologische Reichsanstalt, Wien.

a)

Text-fig. 30.

Greatest thickness	2·3
Actual length	10·6
Actual width	8·7

Original of Laube (1865) pl. X, f. 2 *e*. Apparently the base of a large remiform radiole.

(HMW) In the Hof Museum, Wien.

a)

Text-fig. 31.

Greatest thickness	2·4
Thickness in median line	2·3
Actual length	17·0
Estimated length	20·5
Greatest width	7·5

From the Stuores Mergel, St. Cassian, ex Coll. Klipstein.
The distal end is deeply furrowed.

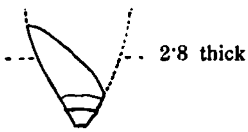
b)

Text-fig. 32.

Greatest thickness . . .	2·3
Thickness in median line . .	2·2
Actual length	19·7
Estimated length . . .	21·0
Greatest width . .	7·4
Width of annulus . .	2·8
Thickness of annulus	2·4

From the Stuores Mergel, St. Cassian, ex Coll. KLIPSTEIN.

c)



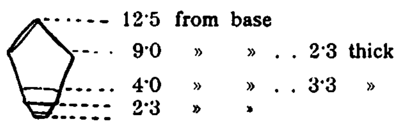
Text-fig. 33.

Width of annulus . .	4·2
Thickness of annulus .	2·7

Numbered «D. 57». St. Cassian, zone of *Trachyceras Aon.*

(BM) In the British Museum.

a)



Text-fig. 34.

Width of annulus . .	4·6
Thickness of annulus	3·3
Height of collerette from annulus . .	ca. 1·9

Registered E 9348. From St. Cassian KLIPSTEIN Collection. The base of a massive remiform radiole, similar to RAW, *a*, but better preserved. This radiole cannot have been much less than 30 mm. long.

b)

Text-fig. 35.

Width of annulus	3·9
Thickness of annulus.	3·0
Height of collerette from annulus	2·9

Registered E 9349. From St. Cassian. KLIPSTEIN Collection. Note the curve of the collerette.

c)

Text-fig. 36.

Width of annulus	4·0
Thickness of annulus	2·7
Height of collerette from annulus	1·8 to 2·6

Registered E 9350. From St. Cassian. KLIPSTEIN Collection.

These specimens are so few and so incomplete that it is impossible to construct any curves. A comparison of the outline drawings with those of *A. testudo* at once shows the larger size of *A. Buchi.* The estimated lengths suggest that the ratio is about 3 : 2; but the ratio of the thickness is rather greater, that is to say the radiole of *A. Buchi* is relatively thicker in proportion to its length than is that of *A. testudo*. The median depression seen in many radioles of *A. Buchi* does not exist in the corresponding radioles of *A. testudo*; it foreshadows the ridges of the spatuliform and trulliform radioles.

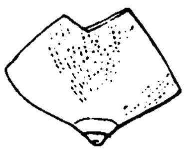
2. Radioli spatuliformes.

(Pl. X, figs. 246, 247, 251, 252.)

The specimens examined are the following:

(MM) In the Palaeontological Museum, Munich.

d)



Inner face

Actual length	17·9
Estimated length	21·9
Actual width	22·6
Estimated width	26 6

Outer face

Text-fig. 37.

Thickness of blade over all	2·0
» » » in median line	1·6
Width of annulus	3·5
Thickness of annulus.	2·4

Original of Münster (1841), pl III, f. 11. Heautotype of *Cidaris Buchi*. Münster's figure, which represents the inner face, is reversed, but Desor's copy of it is turned back again. This face shows the broad ridges. The SW. margin of the outer face is raised, and this feature presumably corresponds to the «marginatis» and «mit einem wulstigen Saume gerandet» of Münster's original diagnosis and description (1829), also to the «à bord saillant» of Desor (1855).

At the back of the tablet bearing this and two small fragments is the label in Münster's handwriting «*Cidarit: Buchii*, S. Cassian nob.»

e)

Text-fig. 38.

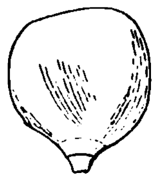
Actual length	8·8
Actual width	8·0
Width of annulus	3·75
Thickness	2·75

This fragment is on the tablet with MM, *d*, and MM, *g*, and being the left-hand one of the three specimens appears to be that designated in the label as «Original-Exemplar — *a*, zu Goldfuss Petrefacta Germaniae I. tb 40 fig. 5». The substance of the specimen is very dark, almost black, and shows no signs of recent fracture. It does not agree with the description or figure of the holotype. In this specimen the base is short, and the acetabulum and annulus are much curved and folded.

No specimen corresponding with the holotype can now be found.

(RAW) In the Geologische Reichsanstalt, Wien.

b)

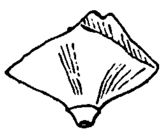


Text-fig. 39.

Greatest length .	. 21·4
Greatest width	. 18·7
Thickness of blade over all . .	2·1
» » » in median line	1·7
Width of annulus . . .	4·3
Thickness of annulus .	2·9

Original of LAUBE (1865), pl. X, f. 2*a*. The ridges are well marked, and there is a slight thickening of the margin.

c)

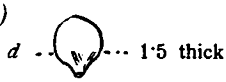


Text-fig. 40.

Actual length	. 20·5
Actual width	. 20·6
Thickness across ridge (*x*—*y*).	3·1
Thickness in median line . .	2·1
Width of annulus . . .	4·6
Thickness of annulus	. 2 7

Original of LAUBE (1865), pl. X, f. 2 *d*.

d)



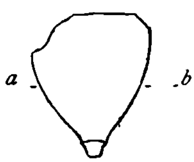
Text-fig. 41.

Actual length . . .	7·6
Greatest width . . .	. 6·4
Annulus not preserved.	

Original of LAUBE (1866), pl. X, f. 2*c*. Probably from a young individual.

(HMW) In the Hof-Museum, Wien.

d)

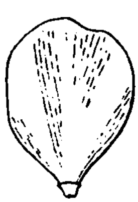


Text-fig. 42.

Actual length	. 17·6
Actual width	. 14·9
Thickness across ridge (*x*—*y*).	2·2
Thickness across *a*—*b* .	2·4
Thickness in median line	2·1
Width of annulus .	3·3
Thickness of annulus.	2·6

Numbered «D. 57». St. Cassian, zone of *Trachyceras Aon.*

e)

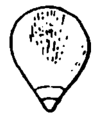


Text-fig. 43.

Greatest length .	. 23·1
Greatest width . . .	. 16·9
Thickness across ridge (*x*—*y*) .	2·0
Thickness of blade over all	2·2
Thickness in median line	1·8
Width of annulus .	3·7
Thickness of annulus.	2·5

From the Stuores Mergel, St. Cassian. Slightly asymmetrical and excavate at the distal end.

f)



Text-fig. 44.

Greatest length	13·1
Greatest width	10·2
Thickness across ridge (*x*—*y*)	1·2
Thickness of blade over all	1·3
Thickness in median line	1·1
Width of annulus	2·8
Thickness of annulus	2·1

From the Stuores Mergel, St. Cassian, ex Coll. KLIPSTEIN. The specimen is slightly crushed.

g)

Text-fig. 45.

Greatest length	6·2
Greatest width	7·8
Thickness across ridge (*x*—*y*)	1·2
Thickness of blade over all	1·5
Thickness in median line	1·1
Width of annulus	1·4
Thickness of annulus	1·1

From the Stuores Mergel, St. Cassian, ex Coll. KLIPSTEIN.

h)

Text-fig. 46.

Actual length	14·1
Actual width	17·8
Thickness across ridge (*x*—*y*)	3·0
Thickness of blade over all	3·2
Thickness in median line	2·5
Width of annulus	4·5
Thickness of annulus	3·1

From Heiligen-Kreuz, Enneberg.

j)

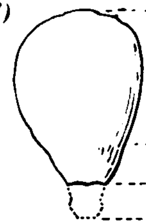
Text-fig. 47.

Actual length	7·8
Actual width	9·2
Thickness across ridge (*x*—*y*)	1·6
Thickness of blade over all	1·8
Thickness in median line	1·45
Annulus not preserved.	

From Heiligen-Kreuz, Enneberg. The outer face of the blade is longitudinally striated in the proximal region only. The pits between the striae are intensified, the striae seeming to anastomose; and in the distal region the anastomoses break up into irregular granules or small pustules.

(BM) In the British Museum.

d)

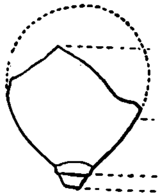


27·0 from acetabulum
18·0 » » 2·2 thick over all, 1·4 thick in median line
9·0 » » 3·3 » » » 2·4 » » »
4·0 » » 2·5 » » »
restored acetabulum

Text-fig. 48.

Registered E 9351. From St. Cassian, Klipstein Collection. Slightly crushed at proximal end; annulus unknown.

e)



18·0 from acetabulum 1·4 thick at point
9·0 » » 2·3 thick over all, 1·8 thick in median line
1·9 » » 3·0 » at annulus; width 4·1
acetabulum. Height of collerette from annulus 1·4 to 1·6.

Text-fig. 49.

Registered E 9352. From St. Cassian, Klipstein Collection. These two radioles are scarcely removed from remiform. There are also in the Klipstein Collection three radioles, more definitely spatuliform, labelled *Cidaris Buchi* by Klipstein (regd. 36524).

Comparison of the Cassian radioli spatuliformes with those from Bakony, shows that, although there are a few quite small specimens, still most of those collected are much larger. No radiole from Bakony exceeds 18·3 mm. in length. MM, *d*, RAW, *b*, *c*, HMW, *d*, *e*, *h*, BM, *d*, *e*, were all well over 20 mm. long, and BM, *d* was probably not the only one that attained 27 mm. Therefore, as with the remiformes, the length of the Cassian spatuliformes to that of the Bakony specimens is 3 : 2. The ratio of thickness to length is about the same in the two species. The essential difference lies in the median excavation, giving rise to lateral ridges, in *A. Buchi.* The extent of this can be gathered by comparing the thickness of the blade over all with the thickness in the median line. Thus in BM, *d*, at 9 mm. from the acetabulum the median excavation is 27·2 per cent of the total thickness at that level; at 18 mm. the excavation has increased to 36·3 per cent. In this specimen the concavity is particularly evident. In the other specimens the maximum excavation is 26·6 per cent (in HMW, *g*), and the minimum is 12·5 per cent (in HMW, *d*). It will be observed that the excavation is quite as obvious in small radioles as in large ones. The ridges are manifest on the inner face, and the excavation of the outer face is very slight or nonexistent. We have already seen that many spatuliform radioles of *A. testudo* have no such concavity, and that, when present, it rarely exceeds 12·5 per cent; only in Jeruzsálemhegy *g* does it amount to as much as 25 per cent, and this is quite exceptional.

The ridges of *A. Buchi*, though visible in the figures of Münster (1841). Desor (1855), Laube (1865), Quenstedt (1875), and Zittel (1879). were not mentioned by any of those authors. They were first alluded to in the description of the trulliform radioles by Benecke (1884).

3. Radioli trulliformes.

(Pl. X, fig. 245.)

The specimens examined are the following:

(MM) In the Palaeontological Museum, Munich.

f) Registered 1894, XIII, 293. From «Stuores Wiesen bei St. Cassian. Mittl. Cass. Sch.» This radiole is almost in the paletiform stage. The absence of characteristic trulliform radioles from the Munich collection is remarkable.

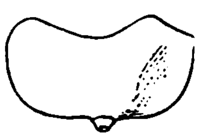
Text-fig. 50.

g) The handle and a small portion of the blade of what may have been a trulliform radiole. Its chief importance lies in the fact that it is borne on the same tablet as the heautotype MM, *d*. Width of annulus 2·7 mm.; thickness of annulus 1·9 mm.; height of collerette 0·6 mm. to 1·1 mm. Blade crushed. Along the edge where the outer face bends sharply from the slope of the handle, the shiny epistereom is raised in a denticulate ridge. From St. Cassian.

See Pl. X. fig. 245.

(HMW) In the Hof-Museum, Wien.

k)

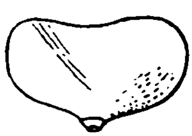


Text-fig. 51.

Greatest length	14·1
Greatest width	24·8
Thickness across ridge (*x*—*y*)	2·4
Thickness of blade over all	2·6
Thickness in median line	1·8
Width of annulus	3·2
Thickness of annulus	2·2

From the Stuores Mergel, St. Cassian, ex Coll. Klipstein.

l)



Text-fig. 52.

Greatest length	14·2
Greatest width	23·4
Thickness across ridge (*x*—*y*)	1·8
Thickness of blade over all	2·6
Thickness in median line	1·5
Width of annulus	3·6
Thickness of annulus	2 3

From the Stuores Mergel, St. Cassian, ex Coll. Klipstein.

m)

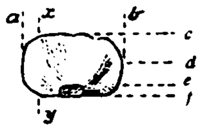
Text-fig. 53.

Actual length . . .	7·6
Greatest width	11·0
Thickness across ridge (*x*—*y*) . .	2·0
Thickness of blade over all .	1·9
Thickness in median line . .	1·2
Annulus not preserved.	

Numbered «D. 57». St. Cassian, zone of *Trachyceras Aon.* The small size and the shape show that this is almost in the paletiform stage.

(BM) In the British Museum.

f)

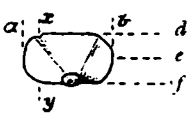


Text-fig. 54.

Length *c*—*f*	8·5
Width *a*—*b*	13·0
Thickness along *x*—*y* .	2·0
Distance *d*—*f*	4·25
Thickness over all at *d* . .	2·3
Thickness in median line at *d* .	1·8
Thickness at *e*	3·5
Width of collerette . .	3·1
Thickness of collerette	1·8
Annulus broken off.	

Registered E 9353. St. Cassian, Klipstein Collection.

g)

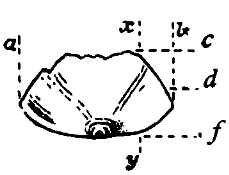


Text-fig. 55.

Length *c*—*f* . .	6·9
Width *a*—*b*	11·6
Thickness along *x*—*y*	1·3
Distance *d*—*f*	3·45
Thickness over all at *d* . . .	1·7
Thickness in median line at *d* .	1·5
Width of annulus	2·1
Thickness of annulus . . .	1·9

Registered E 9354. St. Cassian, Klipstein Collection.

h)



Text-fig. 56.

Length *c*—*f*	11·0
Width *a*—*b*	20·0
Thickness along *x*—*y* .	1·6
Distance *d*—*f*	5·5
Thickness over all at *d* . . .	2·1
Thickness in median line at *d*	1·6
Width of annulus	3·2
Thickness of annulus . .	2·5

Registered E 9355. St. Cassian, Klipstein Collection.

It is in the Radioli trulliformes that the distinctness of the two species is most manifest.

As usual *A. Buchi* attains a greater size. In it the ratio of width to length has only once been found as high as 181 : 100, namely in BM, *h*, whereas in

A. testudo it exceeds 200: 100 in nearly all the specimens and in *k* and *r* reaches 234 and 246: 100 respectively, or 256: 100 if the blade alone be considered.

In the remiform and spatuliform radioles, the blade appeared relatively thicker in *A. Buchi*, but it was not found possible to prove this by measurement. In the trulliform radioles more exact comparison is possible and proves the relative tenuity of *A. testudo*. This is best seen by taking the ratio of thickness in the middle line at the equator to the length of the blade, and especially by selecting for comparison radioles of about the same shape. Thus in *A. Buchi* BM, *f*, this ratio is 0·211, while in *A. testudo g* it is 0·174 and in *k* it is 0·126. Again in *A. Buchi* BM, *g*, the ratio is 0·217, while in *A. testudo h* it is 0·147, and in *s*, 0·139.

If the measurements right across the blade or along *x—y* be compared, the relative thickness of *A. Buchi* is still greater owing to the presence of the ridges. These, which are almost imperceptible or entirely absent in *A. testudo*, are always obvious in *A. Buchi*. In the words of Benecke, «Auf der einen Fläche [i. e. the inner face] zwei ganz stumpfe Kanten von dem Kegel nach den distalen Ecken laufen und die eine Fläche des Radiolus daher .... in drei Felder zerfällt.»

The trulliform radiole *f*, a normal example of *A. testudo*, may be compared with Benecke's excellent description of the corresponding radiole in *A. Buchi* and with the British Museum specimens (*f*, *g*, *h*.).

First, as to outline. Benecke describes and figures the proximal margin as a continuous curve. The SW. and SE. sides seen in *A. testudo* are not distinct from the S. side in *A. Buchi*. Benecke's further statement that this curve bends round and joins the distal (N.) margin in a curved line is applicable to BM, *f*, but not entirely so to BM, *g*, and *h*, since in both of these distinct NW. and NE. sides are developed. In BM, *h*, the extreme length and straightness of those sides is to some extent due to fracture, and that is how Benecke explains other cases. This, however, is certainly not the case with the NW. side of BM, *g*, as seen from the outer face; and signs of bevelling lead to the inference that there were distinct NW. and NE. sides in *h* also.

Benecke says: «der distale Rand des Radiolus ist gerade». This, were it so, would constitute another difference from *A. testudo*; but Benecke's own fig. 1 shows a distal margin with a sinuous outline similar to that above described for *A. testudo*, though the curves are perhaps not so marked. There was apparently a similar curve in BM, *h*; but in BM, *g*, the distal margin has an almost imperceptible concavity, whereas in BM, *f*, it is slightly convex. This uncertainty of outline in *A. Buchi* is in contrast with the marked double curve seen in all trulliform radioles of *A. testudo*, though sometimes more and sometimes less marked than in specimen *f*.

Next, as to the form of the outer face. Benecke's description of it as «etwas wellig gebogen» lacks precision. It is somewhat regularly convex in BM, *f* and *g*; but in BM, *h* there is a median depression, similar to that described in *A. testudo* but more marked.

As regards the proximal margin, presumably of the outer face, Benecke says that it has, «nach seinem Aussehen zu urteilen, einem anderen Radiolus zur Unterlage gedient». Probably he is referring to a distinct slope or bevel of this margin, though he does not describe any such. This bevel exists in BM, *g* and *h*, but, since it approaches the slope of the whole surface more nearly than in *A. testudo*, it is broader and less distinct than in that species; it also differs in becoming wider instead of narrower towards the median line, a feature which may, however, have varied with the shape of the adapically adjacent blade.

In the absence of distinct SW. and SE. sides, there are of course no distinct SW. and SE. bevels.

Next, as to the form of the inner face. The distinctive ridges of *A. Buchi* have already been described. These ridges are emphasized by the meeting of the bevels along the N., NW., and NE. sides. The bevels, however, are not so sharply cut as in *A. testudo*, and are not be detected in all specimens. In *A. Buchi* the handle and base appear to be rather longer and less flattened than in *A. testudo*, and the acetabulum is less bent southwards; but for a fair comparison a larger series of *A. Buchi* is needed.

Lastly, as to ornament. That of *A. Buchi* is described by Benecke as consisting of «feinen, radial auslaufenden Streifen» on the inner face, whereas «die andere Fläche ist glatt». Better preserved specimens than those accessible to Professor Benecke show that the outer face also may be striated, just as is the case in *A. testudo*. The direction is also the same, with a certain modification due to different outline.

The inner face of BM, *h*, clearly shows radiating striae, of which those passing towards the distal margin have a curious, wavy course. The striae that meet the long curved southern margin (= SW., S., and SE., of *A. testudo*) pass over it as in *A. testudo* (Text-fig. 18, Inner face); but then instead of those to the SW. and SE. crossing the others (Text-fig. 18, Outer face) they continue their radiation towards the distal margins. Their course is, in fact, more like that in the spatuliform radioles. This, no doubt, is why there is no trace of concentric ridging. In many cases, however, the continuation of the striae on the outer face cannot be detected; instead, the surface is merely punctate, or sometimes slightly granular, with no definite arrangement of the markings. Such surfaces are probably those which Professor Benecke describes as «glatt».

This comparison of the trulliform radioles not only brings out most clearly the distinctness of the two species, but also shows that *A. testudo* is more specialised than *A. Buchi*. The chief evidences of specialisation are the greater relative width, the more angular and more definite outline, the more clearly cut bevels, and the curious crossing of the striae on the outer face.

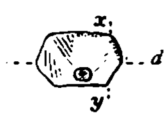
4. Radioli paletiformes.

(Pl. X, figs. 253—255.)

The specimens examined are the following:

(MM) In the Palaeontological Museum, Munich.

h)



ext-fig. 57.

Greatest length	6·8
Greatest width	10·7
Thickness of blade along line *x*—*y*	1·2
Thickness of blade along line *d* . . .	1·7
Thickness in median line at same level	1·5
Width of collerette (annulus broken) .	2·0

This is the specimen figured by Zittel (Handbuch, p. 486, Fig. 344, right-hand) as an interambulacral plate. From St. Cassian.

j)

Text-fig. 58.

Greatest length	9·6
Greatest width	15·2

Registered 1877, X, 758. From St. Cassian.

k)

Text-fig. 59.

Greatest length	7·3
Greatest width	10·6

From Pachycardientuffe of Frombach, Seiser Alp. Note the bevelling of the NW., N., and NE. margins.

(RAW) In the Geologische Reichsanstalt, Wien.

e)

Text-fig. 60.

Greatest length	5·9
Greatest width	10·0
Thickness along line *x—y*	1·6
Thickness in median line	1·4

Original of Laube (1865) pl. X, f. 2 *f.*

(HMW) In the Hof-Museum, Wien.

n)

Text-fig. 61.

Greatest length	8·8
Greatest width	10·6
Thickness along line *x—y*	1·3
Annulus	1·6 × 1 7

Height from acetabulum to outer face 5·1. The same measurement in three other specimens of this form is 4·8, 4·1, and 3·9.

From Stuores Mergel, St. Cassian.

o)

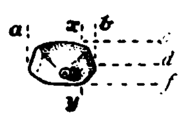
Text-fig. 62.

Greatest length	7·3
Greatest width	7·8
Thickness along line *x—y*	1·3
Thickness across blade	1·5
Thickness in median line	1·0
Annulus	2·0 × 1·8
Height from acetabulum to outer face	3·3

Registered, 1865, L 247. St. Cassian.

(BM) In the British Museum.

j)



Text-fig. 63.

Greatest length, *c*—*f*	5·5
Greatest width, *a*—*b*	8·8
Thickness along line *x*—*y*	1·4
Thickness across blade at level *d* . .	1·9
Thickness in median line, same level .	1·5
Annulus	1·7×1·7

Registered E 9356. From St. Cassian, Klipstein Collection.

k, *l*, *m* Three small specimens more strictly paletiform than *j*. Two of them are broken. Registered E 9357—9. From St. Cassian, Klipstein Collection.

Paletiform radioles of *A. Buchi* are rare. Only fifteen are known to me, and of these some scarcely differ from trulliform radioles. Most are six-sided, but the sides are more rounded and less clearly cut than in *A. testudo;* see, for example, MM, *j*, and RAW, *e*. Three or four specimens are five-sided, with rounded angles.

The paletiform radioles of *A. Buchi* further differ from those of *A. testudo* in the greater thickness of the blade; in the greater prominence of the ridges running from the handle to the distal angles; and in the frequent concavity of the outer face. Specimen BM, *m* (registered E 9359) shows these points of difference in a high degree. Its blade is five-sided; but as viewed from the inner face (fig. 255), the SW. side is much longer than the SE. side, and meets it at a very obtuse angle, so that the blade appears almost four-sided. The N. side is deeply concave; the NE. and NW. sides wavy; the angles rounded. The ridges are particularly prominent, and, where they converge, the handle rises up suddenly as a tapering pillar to a height of 3·3 mm. exclusive of the actual base, which is not preserved (fig. 254). The handle is distant from the S. margin by more than one-third the length of the blade. The outer face is deeply excavate (fig. 253).

In the absence of intermediate trulliform radioles, Zittel might well mistake these curious bodies for interambulacral plates; but it seems a strange coincidence that he should have associated them with the remiform and spatuliform radioles of the species to which they actually belong. The subsequent discovery of trulliform radioles led both Zittel and Benecke to the correct interpretation of the paletiformes as radioles. Benecke, however, does not seem to have appreciated fully the difference between paletiformes and trulliformes, but regarded five-sided specimens of the former as merely broken specimens of the latter. He says: «der angeblichen Nahtflächen der Asseln . . . sind . . . Bruchflächen des späthigen Kalkes». This explanation cannot apply to material now available.

The trulliform and paletiform radioles bought by the British Museum in 1851 from Klipstein were labelled by him with a new specific name in MS. They have, none the less, always been placed by the officials of the museum with the radioles labelled *Cidaris Buchi.*

It has now been demonstrated that there are two distinct species of *Anaulocidaris: A. Buchi* in the Tyrol, and *A. testudo* in Bakony. It has further been shown that *A. testudo* is more specialised than *A. Buchi,* and, since it is found at the higher Raiblian horizon, it may reasonably be regarded as a descendant of the Cassain species.

The preceding description may be summarised in the following:

Diagnosis of *A. Buchi.* — An *Anaulocidaris* with relatively stout radioles: Radioli remiformes very slightly or not at all curved downwards, often slightly concave on inner face (length may exceed 20 mm.); Radioli spatuliformes with handle and blade in a continuous curve, concavity of inner face greater than 0·125 of thickness of blade, often greater than 0·25, distinct ridges from handle to distal margin; Radioli trulliformes with width never attaining twice the length, ridges from handle to distal angles well marked, outline four sided with rounded angles, distal margin straight or variously curved, proximal margin a continuous curve with a single often indistinct bevel on outer face, the striae passing over this are not cut across by any other striae; Radioli paletiformes with curved sides, obscurely bevelled on outer face, which is often concave, blades stout with distinct ridges on inner face.

We have still to consider whether all the Tyrolese specimens are *A. Buchi.*

Those from the Pachycardientuffe of the Seiser Alp, described by Broili (1904), present a general resemblance to *A. Buchi* rather than to *A. testudo.* Nevertheless they are different.

The seven specimens already collected for the Munich Museum are all small, being even smaller than the average *A. testudo.* The remiform radioles of Broili's plate XVII, ff. 46 and 48, have the handle more inclined to the blade than is the case with the corresponding radioles in either *A. Buchi* or *A. testudo.* The acetabulum of these two specimens is not preserved. The coarsely granular outer face. accurately represented in f. 48, is not paralleled in either of those species; but in these radioles from the Pachycardientuffe this face is always, as Broili says, «leicht granulirt». The trulliform radiole (f. 47) has the ridges characteristic of *A. Buchi*, but has a ratio, width : length : : 196 : 100, which is closer to that of *A. testudo.* We have already noted the strongly bevelled margins of the paletiform radiole MM, *k* (Text-fig. 59). All these differences render it advisable to distinguish this form as at least a mutation of *A. Buchi*, by the name

Anaulocidaris Buchi granulata mut. nov.

Diagnosis. — *Anaulocidaris Buchi* with radioles of small length and breadth, the outer face granulate, remiformes having handle inclined to blade at 47°—53°, trulliformes with width of blade nearly twice the length.

Holotype, the original of Broili's pl. XVII, f. 47, preserved in the Palaeontological Museum, Munich; from the Pachycardientuffe of the Seiser Alp.

A proximal fragment of a remiform radiole from the Raiblian Cardita Schichten of Rammelsbach Seehaus was figured by S. v. Wöhrmann (1889, pl. V, f. 15), and referred by him to *Cidaris Buchi.* It is preserved in the Palaeontological Museum, Munich, and one can only say that it is very small for that species and should not be placed in it without question.

Another radiole of this genus from the Cardita Schichten is in the same museum, and comes from Haller Salzberg near Innsbruck. This is a spatuliform radiole (Pl. X, fig. 250) incomplete distally, and measuring:

Actual length	13·4	mm.
Greatest width	17·9	»
Thickness across blade	1·3	»
Thickness in median line	0·9	»
Thickness along *x—y*	1·1	»

In general appearance and thinness it reminds one of *A. testudo*, but the size is rather large for that species, and the excavation (30 per cent of the thickness) is more appropriate to *A. Buchi.*

Probably both these radioles from the Cardita Schichten represent a species descended from *A. Buchi* and not so different from it as is *A. testudo.* More specimens are needed to settle the matter.

Nature and relations of the Radioles in *Anaulocidaris.* — In attempting an explanation of the peculiar shapes of these radioles, comparisons have been made with two living echinoids. BENECKE (1884) was the first to compare the trulliform radioles with the large radioles that in the recent Echinometrid *Colobocentrotus atratus* form a sort of tesselated pavement over all the upper half of the test. DOEDERLEIN (1886) compared the paletiform radioles with the «schildförmigen Stacheln» which in *Goniocidaris clypeata* «bilden ein förmliches fast geschlossenes Dach über der Apicalfläche des Seeigels». The complete series of radioles from Bakony for the first time permits of an exact comparison and reconstruction.

The radioles in question are all primary radioles, borne, as was correctly supposed, by the main interambulacral tubercles of a Cidarid. Over the greater part of the test no other radioles of any importance could have found place, and the plates of the test (if correctly referred to this genus) prove in fact that no other radioles were borne by the interambulacrals.

The Radioli remiformes were, one must suppose, confined to the adoral surface of the test, where they probably served chiefly for locomotion.

The Radioli spatuliformes clothed the succeeding infra-ambital region. The blades were directed downwards, and the blade of each overlapped the handle and part of the blade of a radiole below. Owing to the alternation of the interambulacrals and of their tubercles, these radioles also must have alternated, and must thus have been arranged like the scales of a fish. They were not, however, closely pressed to the corona, but spread outwards, and formed a kind of frill round the base of the urchin.

The Radioli trulliformes protected the greater part of the supra-ambital region. They alternated and overlapped in the same way as the spatuliformes, the N. margin being adoral, but the overlapping was confined to the bevels. Their hexagonal outline shows that no gaps were left in this outer covering. This close juxtaposition of the blades prevented lateral motion of the radioles, but they could be slightly depressed, without, however, losing contact. Hence the transverse extension of the acetabulum and tubercle.

Allusion has been made to a slight asymmetry in the spatuliform radioles of *A. Buchi* by LAUBE, and in the trulliform radioles by BENECKE. Similar asymmetry is sometimes noticeable in *A. testudo.* In so far as this has any meaning, it may perhaps be due to the probable fact that these radioles, though borne only by interambulacrals, covered the ambulacra as well as the interambulacra. Thus each radiole would tend to be wider on its adambulacral side, especially as the tubercles were not shifted towards the adradial margin in any conspicuous degree.

The Radioli paletiformes were erected above the apical region, where they protected the various orifices. Clearly their edges were in close contact, and the irregularity of their outline is due to the change required in filling up a roughly circular space with five series or double series of blades. Since these radioles are obvious modifications of the primary interambulacral radioles, it is improbable that any were borne by the plates of the apical system.

It is natural to suppose that the testudo of radioles served to protect, not merely the orifices and the podia, but also the developing young.

The testudo was more highly developed and more closely fitting in *A. testudo* than in *A. Buchi*.

The comparisons with *Colobocentrotus atratus* and *Goniocidaris clypeatus* should not be pushed too far. In *Colobocentrotus* the whole body of the radiole is thickened and it is the truncate ends that form the pavement. In *Goniocidaris* the shield formed by some of the radioles is a mere expansion of their ends; it is not derived from a previous widening of the shaft to form a blade. Therefore, as Doederlein justly says (1887, p. 15), *Anaulocidaris* and *Goniocidaris clypeata* «are extreme end-forms of two totally distinct evolutionary series, which have attained an outward similarity in this respect». In *G. clypeata*, however, a testudo can scarcely be said to exist, so that there is room for much further development in that direction.

«*Cidaris*» *alata*.

1840. *Cidaris* (?) *alata* L. J. R. Agassiz: Cat. syst. ectyp. Ech. Mus. Neoc., p. 10. Numeri X. 7, 8, 14, 23, 11, 22, 26.
1840. *Cidaris alata* L. J R. Agassiz: 'Descr. Echinod. foss. de la Suisse'. Nouv. Mém. Soc. Helvét. IV, p. 74, 105, pl. xxia, f. 5, *a*, *b*.
1841. *Cidaris alata* Ag., Münster: Beitr. z. Petrefactenk. IV, p. 47, pl. iv, f. 2, *a*—*g*; said to include *C. Waechteri* Wissmann MS.
1841. *Cidaris semicostata* Münster: Beitr. z. Petrefactenk. IV, p. 45, pl. iii, f. 20 *a*, *b*.
1846. *Cidaris alata* Ag. (pars), Agassiz & Desor: 'Catal. raisonn. Ech.' Ann. Sci. Nat. (3) Zool. VI, p. 331; and 1847, separate issue, p. 27.
1849. [1850.] *Cidaris subalata* A. C. D. d'Orbigny: Prodr. Pal. stratigr. I, p. 205.
1855. *Cidaris alata* Ag., E. Desor, Mars: Synops. Ech. Foss., p. 19, pl. ii, f. 5.
1855. *Cidaris semicostata* Münst., E. Desor: Synops. Ech. Foss., p. 20, pl. ii, f. 13.
1865. *Cidaris alata* Ag. (pars), G. C. Laube: Denkschr. Akad. Wiss. Wien, Math.-Nat. Cl. XXIV, Abth. 2, p. 286, pl. viii *b*, f. 8.
1865. *Cidaris semicostata* Münst. (pars), G. C. Laube: Denkschr. Akad. Wiss. Wien, Math.-Nat. Cl. XXIV, Abth. 2, p. 289, pl. x, f. 3.
1875. *Radiolus alatus* Ag, cf. *alatus*, et var. *cimiciformis* A. Quenstedt: Petrefactenk. Deutschlands, pp. 200—202, pl. lxviii, ff. 100—118.
1900. *Cidaris alata* Ag., E. K Hesse: N. Jahrb. f. Min., Beil.-Bd. XIII, p. 230.
1900. *Cidaris semicostata* Münst. (pars), E. K. Hesse: N. Jahrb. f. Min., Beil.-Bd. XIII, p. 231.
1904. *Cidaris alata* Ag. (?), F. Broili: 'Pachycardientuffe d. Seiser Alp.', Palaeontogr. L, p. 155, pl. xvii, f. 52—54.
1904. *Cidaris semicostata* Münst (pars), F. Broili: op. cit. p. 157, pl. xvii, f. 37—41.

Cidaris alata is here distinguished from the following species, which have been referred to it, or to its synonym *C. semicostata*, by various authors:

Cidaris sp. A. v. KLIPSTEIN, 1843: Geol. Östlich. Alpen, p. 273, pl. xviii, f. 14 *a—g* [*C. alata* apud LAUBE, *C. semicostata* apud BROILI].

Cidaris d'Orbignyiana A v. KLIPSTEIN, 1843: Geol. Östlich. Alpen, pl. xviii, f. 5: non *C. orbignyana* AG. 1840. Synn.: *C. Klipsteini*, J. MARCOU, 1847, in AGASSIZ & DESOR: Catal. raisonn. Ech. p. 140 (non *C. Klipsteini* DESOR, 1855). *C. ampla*, DESOR, 1858: Synopsis des Echinides p 484 [*C. semicostata* apud LAUBE et BROILI].

Cidaris perplexa DESOR, 1855: Synopsis des Echinides, p. 21, pl. ii, f. 15. Syn.: *Cidaris spinulosa* A. v. KLIPSTEIN, 1843: Geol. Östlich Alpen, p. 271, pl. xviii, f. 10 *a—c* (non *d—g*) (non *C. spinulosa* AG. 1847) [*C. semicostata*, apud LAUBE, HESSE, BROILI].

Cidaris dorsata BRONN in MÜNSTER, 1841: Beitr. z. Petrefactenk. IV, pp. 16 & 46, pl. iv, f. 1 *a—g*. [*C. alata*, apud AGASSIZ, DESOR, MARCOU. KOECHLIN-SCHLUMBERGER, on the other hand, referred *C. alata*, *C. semicostata*, et al. to *C. dorsata*.]

Cidaris austriaca DESOR, 1855. Synops. Ech. foss. p. 20, pl. ii, f. 14. Syn.: *C. ovifera*, A. v. KLIPSTEIN, 1843: Geol. Östlich Alpen, p. 271, pl. xviii, f. 8 *a*, *b*, non AGASSIZ [*C. semicostata* apud LAUBE et BROILI.]

This is not the place in which to discuss the above references. Suffice it to say that in the case of KLIPSTEIN's species my opinions are based on a study of his original specimens in the British Museum, which have, it appears, not been seen by previous writers. I have also examined the originals of MÜNSTER, LAUBE, and BROILI, as well as the abundant material in the British Museum, collected mainly by KLIPSTEIN. The most important specimens are, of course, the syntypes of AGASSIZ. Of these the Zoological Department of the British Museum possesses four plaster casts, bearing the numbers X8, X11, X14, X23, as attached by AGASSIZ.

The two decisions that have an immediately practical bearing are the inclusion of *C. semicostata* in *C. alata*, and the exclusion of *C. dorsata*. These need some defence.

The radioles termed *Cidaris semicostata* appear to be the smaller radioles from the oral region of individuals that bore the normal forms of *C. alata* in the ambital region. The two forms are similar in minute structure, as shown by HESSE (op. cit. p. 230), and have been separated because of some supposed differences in shape or ornament. It is not easy, however, to gather from the published diagnoses and descriptions what the distinction may be.

Comparison of MÜNSTER's two diagnoses shows that the only character peculiar to *C. semicostata* is the presence of four or five sharp longitudinal ribs on the distal half of the adoral face; while the only character confined to *C. alata* is the possession of a sharp keel on each side. The text is clear enough but does not harmonise with the plates: fig. 20 *b* of *C. semicostata* has at most indications of two ridges; while the ridges of *C. alata* fig. 2 *f* are scarcely to be distinguished from those of *C. semicostata* fig 20 *a*. Again, the lateral keels in *C. alata* figs. 2 *f* & *d* do not appear very different from the sharp flattened sides clearly indicated in both figures of *C. semicostata*.

LAUBE's diagnoses are sufficiently distinct, but are contradicted by his own descriptions and figures, as well as by those of MÜNSTER. Thus *C. alata* has «colli brevi», while *C. semicostata* has »collis longus«; but the description of *C. alata* says «deutliche lange Hals». LAUBE's figures show the collerette (Hals) of *C. alata* as long as, or even longer than, in *C. semicostata*. Then under *C. alata* one reads «facie granulosa», and under *C. semicostata* «facies glabra vel striata»; since the adapical surface is almost invariably granular in these radioles, the word «facies» can only refer to the adoral surface; but we are told that in some radioles of *C. alata* «gewöhnlich an verkürzten Individuen . . . . die Granulation auf dieser Seite ganz fehlt, dagegen eine Anzahl vom Scheitel ausgehender Furchen über dieselbe verläuft . . . . zuweilen nur bis in die Mitte des Stachels» — precisely as in *C. semicostata*. The grooves in *C. semicostata* may, according to LAUBE, extend to the collerette, and this further reduces the difference between the species. Chief stress is laid on the «processus laterales aliformes», which are said by LAUBE to separate *C. alata* from all other Cassian species; but similar wing-like projections are shown in his figures of *C. semicostata* especially figs. 3 *c*, *d*, *e*, which may be compared with figs. 8 *g* & *m* of *C. alata*. The margin of the acetabulum in *C. alata* is said to be smooth, but in *C. semicostata* either smooth or crenelate — only smooth according to MÜNSTER. Actual specimens do not support the attempted diagnoses any better than do the figures There remains the sole statement that in *C. semicostata* «die Gelenksgrube» is «vorgezogen und sehr ausgedehnt» («protracta expansa»). I presume this to mean: directed towards the adapical surface of the radiole and widened transversely to that direction. This is not shown in the figures, and, in so far as any difference is visible in the specimens, which is very slightly, it corroborates my view that the difference between the two forms is due solely to their position on the test.

The relations of the normal *C. alata* to *C. dorsata* are of a different nature. It would be easy to prove, as many authors, from MÜNSTER downwards, have maintained, or suggested, or tacitly admitted, that no sharp line can be drawn between these two forms. It is easy to produce specimens that cannot be placed with certainty under one name rather than the other. Thus, the sole feature that distinguishes certain radioles of *C. alata* from certain of *C. dorsata* is the lateral keel; but this may be very slightly developed, and all stages may be observed between the somewhat flattened radiole more coarsely granular on the front than on the back, through radioles in which the granules along the sides are enlarged into spinules, and those in which the bases of these spinules have coalesced to form the lateral keels (see the three specimens in the British Museum, E 4514, handed over as *C. dorsata* by KLIPSTEIN, but transferred to *C. alata* by my predecessor, J. W. GREGORY). The formation of a keel is in fact merely an intensification of the natural tendency of the granules to lie in longitudinal rows. On the other hand, the available evidence contradicts the assumptions: that flattened, keeled radioles of «*alata*» type were associated in any individual with the more club-shaped radioles of «*dorsata*» type; that, for instance, one kind was confined to a particular region of the test while other regions bore the other kind; or that one kind was characteristic of the youth of an individual, the other kind prevalent in its age. That the contrary was the case appears to follow from the fact that radioles of «*dorsata*» and «*alata*» type respectively are found of all sizes as well as of various shapes that can be correlated with the different regions of the test. It is possible to sort almost the whole of the St. Cassian material at my disposal into two series: *alata* and *dorsata*; and between these obvious series, intermediate forms are relatively few. Therefore, on the principles laid down in the paragraphs on Variation in the Radioles (p. 136), the distinction of the two species is justified.

It is quite likely that these two species, *C. alata* and *C. dorsata*, are both descended from a single ancestral species with more regularly claviform or baculiform peripheral radioles. Two bits of evidence point in this direction.

First, it should be noted that the cotypes of AGASSIZ by no means represent the norm of the species as developed at St. Cassian: they are distinctly more claviform, and bear pustules more equal on the two faces but less regular in distribution. The original specimens were found at Buchenstein; therefore they may not be of the same age as the Cassian specimens, but probably come from Upper Wengen beds.*

It was no doubt some such consideration that led A. D'ORBIGNY to separate from the *C. alata* of AGASSIZ (as a distinct species, *C. subalata*), the Cassian radioles described by MÜNSTER. The name is unfortunate, since the Cassian radioles are more alate rather than less; but it may be of some service to use it in either a varietal or mutational sense, calling the Cassian forms «*Cidaris*» *alata subalata*.

Secondly, it appears that the radioles of «*Cidaris*» *alata* from Bakony may be separated into two sets. Those from the Cassian beds of Cserhát are either like *C. alata typica* or *C. alata subalata*. I am not clear as to the age of bed *i* at Section XI, but one radiole from here is apparently *subalata* while the other is of the usual Raiblian pattern. Radioles of the latter type, as found at Cutting I and at Jeruzsálemhegy differ in various features from both *typica* and *subalata*, and must be regarded, if not as pertaining to a distinct species, at all events as representing a mutation, which I shall name *poculiformis*. Now this form departs from the claviform type far more than does *C. alata subalata*.

The suggestion may therefore be hazarded that *C. alata typica, subalata,* and *poculiformis* constitute an evolutionary series, which has branched off from the line represented by *C. dorsata*. Evidently the *C. dorsata* of the Cassian and Raiblian beds cannot itself be the ancestor; but it may be regarded as having maintained the radiole characters unaltered. A form with similar slightly flattened radioles probably preceded *C. alata typica*, and was in its turn descended from a form with regular claviform or subcylindrical radioles.

The frequent appearance of ridges does not, so far as I can see, point to an ancestor with longitudinally ridged radioles. It is obvious that these ridges either are composed of fused pustules, or tend to break up into pustules. The next stage either preceding or succeeding, consists of pustules arranged in longitudinal rows, sometimes with a trace of transverse rows as well. In the next stage, the pustules are irregularly dispersed. That the direction of evolution was at first from the irregular arrangement, through the linear, up to the ridges, and not *vice versa*, is the view that accords better with the supposed order: *typica*, *subalata*, *poculiformis*, and with the supposed descent from the *C. dorsata* type; it is also the view more in harmony with the stratigraphical distribution of the forms. But, accepting this view, it must be admitted that the tendency to ridges did not progress far: in *C. alata poculiformis* one sees rather an increase in size of the adapical pustules with a return to irregularity or even a tendency to transverse rows.

The Microstructure of the Radioles throws some light on the inter-relations of the species and subspecies, and a more exhaustive study than has been possible would doubtless lead to still more definite results. Sections of a typical peripheral radiole of *C. dorsata* from St. Cassian (fig. 438) show no external modi-

* Dr. Maria OGILVIE-GORDON in litt. 26. Dec., 1907, suggests as their probable horizon bed No. 7 of the table facing p. 16 in her paper, Quart. J. Geol. Soc. XLIX; 1893.

fication of the stereom that can be described as a cortex. Hesse (1900, p. 227) notes the absence of this «Deckschicht» or epistereom from all the St. Cassian radioles, and ascribes it to incomplete preservation. In the case of *Cidaris decorata* his explanation is correct, for the structure is to be detected on a section now before me; but probably the cortex was wholly undeveloped in *C. dorsata* and *C. alata*. In its place *C. dorsata* possesses an outer layer of fine, close-set, and regular radiate septa, united by regular and closely spaced trabeculae; in a transverse section across the proximal half of a radiole from St Cassian, with a diameter of about 6·5 mm., this layer extends to a depth of about 0·4 mm. and contains about 48 radiate septa to the millimetre. Where pustules occur on the surface the septa fan out slightly and fresh ones are intercalated. Although the inner limit of this layer is far from following a regular line, still the change to the inner layer is fairly distinct and rapid. The inner layer, which passes right to the centre of the radiole, consists of loculi varying in size and arrangement, but on the whole disposed in rows radiating from the centre; the loculi near the centre and towards the periphery are the smaller; nearly all appear oblong, with the longer axis in the radial line.

A similar section of *Cidaris alata* from St. Cassian (fig. 440) shows several points of difference. The inner layer is composed of more regular loculi, and is therefore less distinct from the outer layer, into which it merges. There is an axial complex of quite irregular loculi; the septa, however, do not radiate from this alone, but from a transverse line separating the inner and outer halves of the blade. Towards the periphery about 32 radiate septa go to the millimetre; near the median transverse line the septa seem to be closer and thicker, as though the vanes were, from their first appearance, composed of denser stereom.

If now we turn to the Raiblian forms of these two species, we find that the essential differences remain, but that each species has changed in a similar direction. The change in each case consists of an increase in size and irregularity of the loculi of the inner layer; thus, in *C. alata poculiformis* (fig. 441) the adcentral loculi of that layer now merge with the axial complex, and in *C. dorsata marginata* (fig. 439) the central loculi no longer retain any trace of radiate arrangement, but are as irregular as those of an axial complex. The differences, as before, consist in the greater closeness of the outer radiate septa in *C. dorsata*, 40—44 to the millimetre, as opposed to 20—25 in *C. alata;* in the greater distinction between these and the inner layer in *C. dorsata;* in the direction of the radiation in *C. alata*, and in the denser stereom of its vane.

The facts of microstructure, then, so far as they have been ascertained, confirm the separation of *C. alata* from *C. dorsata*, and show that there is an internal as well as an external difference between the Cassian and Raiblian forms.

The preceding discussion may be summarised in the following diagnoses.

Diagnosis of «*Cidaris*» *alata*. — A Cidaroid in which the radioles have an irregular microstructure, with axial complex, radiate septa irregularly spaced and sometimes dichotomous, radiating from a median transverse line, and separated by irregularly spaced trabeculae; radiole-shaft normally of sub-lanceolate outline, differentiated into handle and blade, the former smooth or with faint longitudinal striae, the latter with pustulate ornament varying in parts of the surface from smooth to ridged, or again to spinulose. All radioles, except a few circum-apical, dorso-ventrally compressed, the compression being greatest in the peripheral radioles which have slight lateral vanes (alae) separating a more pustulate adapical face of the blade from a smoother adoral face. Collerette short, with fine longitudinal striae.

Type-description: AGASSIZ, 1840, Nouv. Mém. Soc. Helvét. IV, p. 74.

Type-figures: tom. cit., pl. xxi a, ff. 5 *a, b*.

Type-locality: Buchenstein in Ampezzo district, Tyrol.

Lectotype: following DESOR, 1885, I take the original of AGASSIZ' cast X 23 (Pl. XI, fig. 273), said to be in the Berne Museum.

This is divided into three sub-species, probably to be regarded as mutations.

«*Cidaris*» *alata typica*.

(Plate XI, figs. 273, 274.)

Diagnosis. — *C. alata* in which the peripheral radioles are sub-claviform or sub-baculiform, with vanes very slightly developed, pustules subequal on adapical and adoral faces, of relatively moderate size and irregularly disposed; with long axis slightly or not at all bent.

Type-description, type-figures, type-locality, and lectotype, same as for the species.

Material from Bakony. — Perhaps to this form should be assigned two radioles from the Cassian beds of Cserhát (Leitnerhof) lettered *a* & *b*. These are flattened, but with no vanes; the adapical face bears the coarser granules (fig. 274).

«*Cidaris*» *alata subalata* D'ORB.

(Plate XI, figs. 275—279, and Plate, XIV, fig. 440.)

Diagnosis. — *C. alata* in which the peripheral radioles have the blade clearly compressed; with distinct vanes or side-keels, which may meet proximally on the adapical face; with pustules of adoral face usually in longitudinal rows and tending to form longitudinal ridges distally; with coarser pustules on adapical face, displaying a frequent tendency to lie in rows; with longitudinal axis of blade bent more adorally than that of the handle.

Type-description: MÜNSTER 1841, loc. cit. supra.

Type-figures: MÜNSTER 1841, pl. iv, f. 2.

Type-locality: St. Cassian.

Lectotype: the original of MÜNSTER 1841, pl. iv, f. 2 *c*.

Material from Bakony. — Three radioles from the Cassian beds of Cserhát (Leitnerhof), lettered *c* to *e*, and one from Section XI, bed *i*, lettered *a*, seem appropriately placed under this form.

The chief specimen from Cserhát (*c*) is a peripheral radiole (figs. 275, 276), devoid of base, 16·2 mm. long, approaching cylindrical, with slight but distinct vanes; its adoral face bears a fine shagreen ornament, with a slight tendency to run in longitudinal rows; its adapical face bears ornament more pronounced and more linear: the distal end is rounded and bears coarser pustules.

The two other radioles from Cserhát (*d* & *e*) are obscure. In both of them the ornament is markedly linear (fig. 277).

Of the two radioles from Section XI, the one here considered, *a*, (figs. 278, 279) approaches both the infra-ambital form known as *C. semicostata* and a small *C. dorsata*. The other radiole (*b*) from this locality (fig. 280) broadens distally and its adapical face bears strong ornament; it probably belongs to mutatio *poculiformis*.

C. alata poculiformis mut. nov.

(Plate XI, figs. 280—309, and Plate XIV, fig. 441.)

1857. ? *Cidaris alata* AG., F. v. HAUER: Sitz.-Ber. Akad. Wiss. Wien, XXIV, p. 565.

Diagnosis. — *C. alata* in which, as compared with norm. peripheral radioles have as a rule a coarser micro-structure, the radiate septa of the inner layer merging in the axial complex, lateral keels more serrated, and adapical pustules more marked; adapical radioles more differentiated into hollowed forms.

Material. — 33 radioles from the Raiblian beds of Jeruzsálemhegy of which 9, selected for figuring, are lettered *a—j*; these are mostly characteristic, but one or two verge on *C. dorsata*. 9 radioles or fragments of radioles of very diverse shape, from the Raiblian beds of Cutting I on the Veszprém-Jutas railway; 4 are lettered *a—d*. Also perhaps specimen *b* from Section XI.

Specimen *f* from Jeruzsálemhegy, drawn on Plate XI, figs. 301, 302 is taken as holotype.

Description of the specimens. — Infra-ambital radioles appear to be represented by a few small specimens, from Jeruzsálemhegy, of the type usually called *C. semicostata* (vide supra). Two of these, lettered *a* and *b*, are shown in figures 281—286.

The radioles presumed to be ambital or peripheral are still very like the ordinary *C. alata subalata*, although some have stronger pustulation on the adapical face. Two specimens from Jeruzsálemhegy, lettered *c* and *d*, are figured. The former (figs. 287—289) is slightly weathered; in the latter (figs. 290—293) the coarse adapical pustulation, with its tendency to run in oblique rows, is well shown. The following are measurements in millimetres.

	c	*d*
Length	22·2	24·8
Greatest diameter — transverse	7·4	8·4
Greatest diameter — dorso-ventral	4·8	6·2
Diameter at annulus — transverse	1·8	2·3
Diameter at annulus — dorso-ventral	1·5	2·0
Height of collerette	0·9	1·4
Number of pustules in a length of 2 mm. on adapical face	3 to 4	2

There are about a dozen other radioles of this form from Jeruzsálemhegy, and many of them differ still more from the corresponding radioles of *C. alata subalata*. The pustules of the adoral face tend to run in longitudinal series, which at the distal end may form pronounced ridges. The pustules of the adapical face are often still coarser than in *c* and *d*. The lateral keels may be irregularly serrated, owing to the incomplete fusion of the spinelets that form them. Sometimes the pustules are widened and appear as though their ends had been worn into a slight concavity, e. g. specimen *h* from Jeruzsálemhegy (fig. 294). This should not be confused with the structure found in certain radioles called *C. scrobiculata*. In these peripheral radioles the sagittal line of the adoral face is curved concavely in the proximal half of the blade and convexly in the distal half.

The micro-structure of one of these radioles has been described above (see p. 174, Pl. XIV, fig. 441).

The beginning of the modification that affects the radioles presumed supra-ambital is shown by specimen *e* from Jeruzsálemhegy (fig. 295). The adapical face is slightly excavate in its distal half, and the pustules, which tend to lie in oblique transverse rows, begin to assume the form of adpressed spinelets.

From Cutting I comes a fragment of the distal end of a small radiole, lettered *a* (figs. 296—298). This is very thin and the adapical face bears a few large irregular pustules, while towards the margin it is slightly plicated and not pustulate. Towards the distal end of its adoral face the pustules increase in size and are extended, producing the appearance of cylindrical spinelets prone on the surface. This may be the distal end of a radiole similar in form to specimen *j* from Jeruzsálemhegy, (figs. 299—300) but of larger size. In *j* is a curious extension of the vanes into the body of the shaft, producing a form like that described later on as *Radiolus penna*.

The supra-ambital radioles show greater differences from the Cassian forms. A good example is the finely preserved holotype from Jeruzsálemhegy, lettered *f* (figs. 301, 302). This has a beautifully serrate (distally almost plicate) margin all round the blade The smaller pustules on the adoral face are 3 or 4 within a length or width of 2 mm. The pustules in the proximal half of the adapical face are widened and flattened almost like scales in four transverse rows, occupying a length of 7 mm.; at the distal end of the face is a sort of shallow cup, in the middle of which are smaller pustules. A similar feature is observed in other radioles from Jeruzsálemhegy, and in one of those (*b*) from Cutting I. In the latter (figs. 303, 304) the distal end of the adapical face is slightly depressed, and an irregular curved band of pustules forms a proximal border to the depression.

In radioles supposed to come from the adapical region, the further development of this depression or cup has produced the goblet shape that has suggested the name of the mutation. In one of these (*c*), from Cutting I (fig. 305), the bilateral symmetry of the blade is still manifest, the proximal border of pustules is continuous with the distal border of the radiole, and encloses a shallow cup, in the middle of which are a few ridges of pustules. In the other adapical radiole from Cutting I, lettered *d* (figs. 306, 307), the original bilateral symmetry is scarcely to be detected; the bands of pustules are more continuous, almost right round the radiole; the edge of the cup is irregularly plicated in places. The general appearance is that of a cup-coral, with the aspect of an irregular columella produced by the tubercles within the cup.

The radiole last described might well belong to *C. dorsata*, but, since normal examples of that species are not known from Cutting I, it is more likely to be *C. alata*. There is, however, a similar radiole from Jeruzsálemhegy, where *C. dorsata* is fairly common. This radiole, (lettered *g* figs. 308, 309), has a more clearly marked, broad, shallow cup, almost at right angles to the long axis of the radiole, but the shaft shows clearer traces of the original dorso-ventral differentiation than does the poculiform radiole *d* from Cutting I.

Relations of the Mutation. — As previously explained, this is regarded as the last term at present known in the *alata* series, and that series is supposed to have developed parallel to the *dorsata* series. On this view one can understand why, at any stage, there should be a difficulty in distinguishing the least modified or infra-ambital, and the most modified or adapical, radioles of the *C. alata* series from the corresponding radioles in the *C. dorsata* series. The distinction between the normal peripheral radioles will be made clear in the description of *C. dorsata*.

The poculiform radioles with their expanded excavate ends, truncate at right angles to the axis, afford a far truer subject for comparison with the adapical radioles of *Goniocidaris clypeata* than do the paletiform radioles of *Anaulocidaris Buchi*. Indeed figures 17 and 18 on Taf. vi of Doederlein (1887) might almost pass for representations of the radioles described above, so far as mere form is concerned. When Doederlein wrote, the Triassic rocks had yielded no radiole with an «Endkrone». and these from Bakony are the first of that age to be described.

It is also interesting to note the intensification of the pustules into flattened spinelets in this mutation, and to compare it with the flattening of the lateral spinelets in the radioles of *Goniocidaris clypeata* and *G. mikado*, to which Doederlein (p. 34) drew special attention.

The recent Japanese species with adapical radioles resembling those of *C. alata poculiformis* were dredged in Sagami Bay, on a muddy bottom, at a depth of 120—160 fathoms.

«*Cidaris*» *dorsata*.

1841. *Cidaris dorsata* (ex Bronn Ms.) Münster: Beitr. z. Petrefactenk. IV, p. 46, pl. iv, f. 1 *a—f*.
1855. *Cidaris dorsata* Braun in Münster, E. Desor, Mars: Synops. Ech. foss. p. 19, pl. ii, f. 4.
1863. *Radiolus dorsatus* Münst., H. E. Beyrich: Monatsber. preuss. Akad. Wiss. Berlin, Jahrg. 1862, p. 30.
1865. *Cidaris dorsata* Braun, G. C. Laube: Denkschr. Akad. Wiss. Wien, Math.-Nat. Cl. XXIV, Abth. 2 p. 283, pl. ix, f. 12.
1875. *Radiolus dorsatus* Münst. F. A. Quenstedt: Petrefactenk. Deutschlands, III. p. 193, pl. lxviii, ff. 66—78; excl. *C. Hausmanni*, which, however, does not appear to be represented by any of Quenstedt's figures.
1875. *Cidaris foratus* F. A. Quenstedt: tom. cit., p. 195, pl. lxviii, ff. 79—81.
1889. *Cidaris dorsata* Braun, S. v. Wöhrmann: Jahrb. Geol. Reichsanst. Wien, XXXIX, p. 193, pl. v, f. 12. Including synonyms, except perhaps *C. gigantea* Cornalia.
1889. *Cidaris Braunii* Desor, S. v. Wöhrmann, pars, loc. cit. pl. v. f. 14 non f. 13.

The ascription of this species to Braun, by Desor, Laube, and others, is an error. Agassiz & Desor (1847, Catal. raisonnée, p. 27) even went so far as to maintain «*Cidaris dorsata* Braun in Münster» and to make «*Cidarites dorsatus* Bronn» a synonym of *C. alata*. The two are the same species, and the proper way of quoting it is shown in the first entry above. Proof of this statement is afforded by the citation «*Cidaris dorsata* Bronn» in the footnote signed by Braun on p. 16 of Münster's «Beiträge» IV, and by the entry «*Cidaris dorsata* Br. *mss.*; *i.* Mü. Beitr. &c.» in Bronn's «Nomenclator», 1848.

Diagnosis. — A Cidaroid in which the radioles have an irregular microstructure, with no distinct axial complex, radiate septa of inner layer irregularly spaced and sometimes dichotomous, radiating from the axis, and separated by irregularly spaced trabeculae, radiate septa of outer layer finer and more regular; radiole-shaft normally pyriform or subclaviform, without clearly differentiated handle, but covered with pustulate ornament, which may be in linear series but very rarely forms distinct ridges, or may be spinulose. All radioles, except a few circum-apical, dorso-ventrally compressed, but the compression is as a rule slight and not more marked in the peripheral radioles. Pustulation as a rule slightly more marked on the adapical face. Collerette short, with fine longitudinal striae.

Lectotype: the original of MÜNSTER (1841) pl. iv, f. i. *a*; from the St. Cassian beds of St. Cassian district.

As in the case of *Cidaris alata*, the Raiblian specimens of this species represent a distinct mutation, of which the characters are chiefly manifest in the presumed supra-ambital radioles. The mutation may be called *marginata*, and the St. Cassian forms distinguished as *typica*.

«Cidaris» dorsata typica.

(Plate XI, figs. 310, 311 and Plate XIV, fig. 438.)

Diagnosis. — *C. dorsata* in which the pustules on the radioles are as a rule low and not elongate; in which the distal end of the supra-ambital and adapical radioles is conoid or rounded, and not limited by a rim.

Holotype. — The same as the lectotype of the species.

Material from Bakony. — The norm of this species appears to be represented by various fragmentary and ill-preserved radioles from the Cassian beds of the following localities: Cserhát (Leitnerhof), two or three fragments; Veszprém, Giricses Domb, lower stratified limestone, a subclaviform shaft; Veszprém, Takarékpénztár, a large shaft; Section VI Veszprém, a weathered proximal fragment; the same, bed *e* 3, fragment of a globular shaft.

Remarks on the specimens. — These present the various shapes and modes of pustulation noted in the Cassian specimens (MÜNSTER, 1841, pp. 46, 47). It may be surmised that the more baculiform and pyriform radioles are peripheral, that the subclaviform and claviform are supra-ambital, and that the globiform or rapidly expanding radioles are adapical.

The dorso-ventral flattening characteristic of the species is best seen in the subclaviform shaft from Giricses Domb (fig. 311). This is 14·7 mm. long with greatest diameters 7·2 mm. and 6·4 mm., and may be regarded as of average size.

The shaft from Takarékpénztár (fig. 310) is much split, but when complete must have exceeded a length of 40 mm.; its greatest diameters are 13·5 and 12 mm. This does not approach the swollen rounded shape of *C. gigantea* CORNALIA, nor are its pustules arranged in similar longitudinal series.

The fragments from Cserhát are rather doubtful. One of them possibly had an axial cavity, and if so cannot belong to this species.

Considering the abundance of *Cidaris dorsata* at St. Cassian, where it is said to be the commonest Echinoid fossil, its meagre representation in the Cassian rocks of Bakony is remarkable.

Some very small radioles, possibly belonging to this species, are dealt with on a later page, under the heading *«Cidaris»* cf. *dorsata* et *Hausmanni*.

«*Cidaris*» *dorsata marginata* mut. nov.

(Plate XI, figs. 312—333 and Plate XIV, fig. 439.)

Diagnosis. — *C. dorsata* in which the micro-structure is coarser than in the norm, and the radiate septa of the inner layer become adcentrally so irregular as to resemble an axial complex; in which the pustules on the adapical face of the radioles are well marked and frequently produced into depressed spinelets, especially in the supra-ambital radioles; in which the distal end of the supra-ambital and adapical radioles tends to be excavate, and is frequently limited by a rim of confluent pustules.

Material. — It is probably correct to refer all the Raiblian radioles of *C. dorsata* to this mutation, although a few cannot be certainly distinguished from the norm of the species. Thus, I would place here the specimen from the Raibler Schichten of the Wettersteingebirge figured by SCHAFHÄUTL (1865, pl. v, f. 3) as «*Cidaris pirifera* AGASSIZ»; the original is in the Palaeontological Museum, Munich. Similar specimens from the *Cardita* Schichten of Issjöchl are at Vienna (Geolog. Reichsanstalt). A list of Raiblian localities is given by WÖHRMANN (1889). The fragments from Rammelsbach (Seehaus) which he figures (pl. v, f. 14) as *Cidaris Brauni* seem more probably to be this form or possibly *C. alata poculiformis*. Here may also perhaps be placed the «*Cidaris alata* GOLDF.» of SCHAFHÄUTL (1863, Süd-Bayerns Leth. Geogn. p. 341, pl. lxv *f*, f. 23*a, b*, «im schwarzgrauen Thonmergel der Schachenalpe am Wetterstein».

The following localities in Bakony have yielded specimens: Jeruzsálemhegy, about 33; Veszprém-Jutas Railway, Cutting I, 3 ill-preserved fragments.

Holotype. — Specimen *o* from Jeruzsálemhegy (pl. XI, figs. 319—321).

Description of the specimens. — The radioles from Jeruzsálemhegy present an almost complete series, from the small presumably infra-ambital forms, and the pyriform or subclaviform ambital radioles, all of them differing but slightly from the corresponding radioles of the norm, through the more flattened, distally excavate, supra-ambital forms, up to the adapical radioles with truncate excavate ends, closely similar to the adapical radioles of *C. alata poculiformis*. Examples of these different forms from the Jeruzsálemhegy material will now be described in order.

In any well-preserved radiole, from any region, the adoral face is distinguished from the adapical by the smaller size of its pustules, except at the distal end, where the pustules resemble those on the adapical face. Thus in the shaft of a small infra-ambital radiole, lettered *a* (figs. 312, 313), fine pustulation extends about 7·5 mm. out of a total length of 11·2; these pustules are low and about four lie within a length of 2 mm. The distal region of the same face is occupied by two transverse rows of adpressed spinelets, of which three occupy a width of 2·5 mm., and the length of each may be as much as 1·4 mm. The adapical face is irregularly covered by pustules similar to those last described, but not quite so long or so adpressed, especially in the proximal region, where about four occupy a width or length of 2·5 mm. At the sides the pustules are slightly longer and slightly flattened, thus showing a faint tendency to the formation of vanes.

In a small shaft (*b*), 10·3 mm. long, with greatest diameters 6·4 mm. and 4·1 mm., the pustules are much flattened, as though sharing the dorso-ventral compression of the shaft; they project in a proximal direction, contrary to the usual adpressed spinelets of this mutation, though the feature is noted in the proximal region of the adapical face in a few other specimens.

Shafts of normal pyriform shape are represented by specimens *e* and *f*, which are rolled and fragmentary.

The pyriform shape with the first signs of distal excavation is well shown in the shaft *g* (figs. 314—316). This, which seems to be broken off just above the collerette has a length of 25·1 mm. and greatest diameters of 11·6 and 11·0 mm. In the proximal region the pustules are low, especially on the adoral face (fig. 314), and are often hollowed at the ends, as in some specimens of *C. alata poculiformis*, or even turned into slight cavities. In the middle and distal regions the pustules gradually become more prominent and directed distalwards. In the middle region about 3 pustules of the adoral and 2 of the adapical face occupy a width of 2·5 mm. On the rounded distal end (fig. 315) the pustules are again smaller and shorter and are irregularly distributed in such a way as to leave bare patches. On both the adoral and adapical sides of the distal end is an irregular depression, unsymmetrically placed, and containing some pustules.

The slight cavities at the proximal end of the shaft in specimen *g* agree in position with the far more marked holes found in *Cidarites foratus* Quenst. The latter, however, appear to be due to some boring animal (fig. 334), whereas the cavities in specimen *g* are probably due to slight erosion and perhaps natural resorption of the proximal pustules during life; they have been noticed only in this large radiole and can scarcely be seen without a lens. There is a more constant resemblance between this mutation and *Cidarites foratus*, namely the prominence of the pustules (fig. 335). In the case of *C. foratus* I regard that feature as hypertrophy in response to the stimulus of the boring animal, and on that view the species is a synonym of *Cidaris dorsata.* Figure 12 *e* on plate ix of Laube (1865) does in fact represent (though poorly) a specimen referred to *C. dorsata* but in the *foratus* condition. It does not follow that the spinulose pustulation of *C. dorsata marginata* was inherited as an «acquired character» from *C. dorsata* «*forata*».

Smaller radioles of the same general form as *g* are *h*, *j*, *k*, *l*, *m*. The regularly pyriform *h*, which is complete, has a length of 19·4 mm, with greatest diameters 9·7 and 8·7 mm. In these, as well as in *g*, the pustules often run in oblique lines, each pustule lying at the intersection of two lines. One of these lines, starting from the side, near the proximal end, trends distalwards to the middle of the adapical face where it connects with the corresponding line from the other side. Thus these two lines form a wide parabolic curve convex distalwards. The lines crossing the limbs of this, pass on to the adoral surface, where they meet in a parabolic curve of similar position but narrower.

The micro-structure of such radioles is described and compared with that of the norm on p. 174 under *C. alata* (Pl. XIV, fig. 439).

In *m* the base is preserved (fig. 317), and in this radiole the characters of the supra-ambital series just begin to be distinct. The sagittal line of the adoral face forms a slight concave curve, from the annulus almost to the distal end, where it bends suddenly, at little more than a right angle, to the apex (fig. 318). Neither annulus nor acetabulum shows any marked obliquity. Compared with the massive shaft, the acetabulum is small, the annulus slight, and the collerette short: length of radiole, 22·3 mm.; greatest diameters, 9·4 and 8·7 mm.; diameters of annulus 2·4 and 2·3 mm.; from base of annulus to top of collerette 1·2 mm. From the point on the adoral face where the sagittal line bends to the apex, a slightly more confluent row of pustules passes in a slightly proximal direction on to the adapical face, thus tending to form a rim round the distal end. The sagittal line, in passing from the rim on the adoral face to the distal extremity, follows a faintly convex curve; but on the adapical face the corresponding tract follows a faintly concave curve.

In specimens *n*, *o*, *p*, *q*, *r*, the features adumbrated in *m* are intensified, as shown in figures 319—326. The rim round the distal end is more definite and, on the adapical side may be produced downwards in a distinct angle (fig. 321). Thus, as seen from the distal end (fig. 320), the radiole is almost triangular in section. This is the kind of modification that produced the Cassian *Cidaris trigona*, but here it is not carried so far as in that species.

The radioles nearer the apex of the test seem to be represented by forms with less dorso-ventral compression, less marked bilateral symmetry, more regularly pyriform, but with the distal end flattened or truncated, almost at right angles to the axis, and sometimes hollowed, as in *C. alata poculiformis*. Specimen *s* (figs. 327—329) appears to represent the first incoming of this form; its distal end is still slightly rounded, and is strongly spinulose. In *t* (figs. 330—333), which represents the extreme modification in this direction, the rim is almost continuous, and within it, roughly parallel to its edge, are rows of pustules, rising a little higher on the adoral than on the adapical side; the diameters of the truncate top are 10·4 and 10 mm.; it is hollowed excentrically towards the adapical margin.

Relations of the Mutation. — This last form approaches close to that regarded as the extreme adapical form of *C. alata poculiformis*, and it is hard to say to which species the specimens represented in figures 306—309 should be referred. The resemblance between these most modified forms does not prove the specific identity of *C. alata* and *C. dorsata*, for the normal forms of the ambital and supra-ambital radioles are readily distinguished.

A radiole of this last form has been described by QUENSTEDT (1875, p. 194, pl. lxviii, f. 77) as *Radiolus dorsatus* «ein wahrer fungiformis», and said to come from the Cassian beds of St. Cassian. This is the only such form I have ever seen or read of in the Cassian beds, where it must certainly be rare, if inded it is really found in them. Its occurrence does not affect the distinctness of our Raiblian mutation, which is based on other characters.

«Cidaris» scrobiculata.

(Plate XI, figs. 336—339.)

1841. *Cidaris scrobiculata* BRAUN in MÜNSTER, Beitr. z. Petrefactenk. IV. p. 45, pl. iii, f. 21, *a*, *b*.
1865. *Cidaris scrobiculata* BRAUN, G. C. LAUBE, Denkschr. Akad. Wiss. Wien, Math.-Naturw. Cl., XXIV, Abth. 2, p. 285, pl. viii *b*, f. 7.
1904. *Cidaris dorsata* BRONN in MÜNSTER (pars), F. BROILI, Palaeontographica, L, p. 153.

Diagnosis. — A Cidaroid with main radioles not exceeding 15 mm. in length, having a pyriform, globose, or truncate-conical shaft, the surface of which is covered with small deep pits irregularly distributed and having a granular border apparently of fused pustules.

BRAUN's description (1841) runs: «Diese seltenen kleinen birnförmigen Stacheln zeichnen sich durch die unregelmässig auf der ganzen Oberfläche vertheilten tiefen Grübchen aus, an deren Kanten sich keine Knoten oder Warzen zeigen. Der Gelenkkopf ist glatt, der kurze Stiel und der ringförmige Leisten fein gestreift.»

The species was accepted by every author down to and including LAUBE (1865), who, however, substituted «kugelförmig» for «birnförmig», adding «zuweilen auf dem Scheitel abgeplattet». His diagnostic statement, «colli, brevi, forti, fossa articulari magna», is not applicable to all specimens. As regards the surface ornament, he specially mentions granules, and says that the pits occur between them, while towards the distal end the pits may occasionally give place to rounded pustules. Granules are in fact so easily seen, and it is so obvious that the walls of the pits are composed of fused pustules, that one suspects BRAUN's «keine Knoten u. s. w.» to be a misprint for «kleine Knoten u. s. w.»

QUENSTEDT (1875, p. 194) seems to have been unacquainted with true specimens of this species, but compared the form with that of similar small radioles assigned by him, no doubt correctly, to *C. dorsata.*

BROILI (1904), after study of the original material and of radioles from the «Pachycardientuffe» of the Seiser Alp, has made the species a synonym of *C. dorsata.*

Material from the Tyrol. — The British Museum contains six radioles labelled «St. Cassian» from the KLIPSTEIN Collection, No. 642 (regd. 36489 & E 9464), and 12 specimens out of the material reported on by BROILI, from the Pachycardientuffe, Tschapit-bach, Seiser Alp. (regd. E 4702, E 9463). In addition to these, I have examined the original specimens at Munich and Vienna.

Dr. BROILI (1904), while recognising that his material from the Pachycardientuffe agrees, in the main, with *C. scrobiculata*, has made that name a synonym of *C. dorsata*. His reasons appear to be: 1. that in the Cassian beds *C. scrobiculata* is rare; 2. that the radioles from the Pachycardientuffe may owe their peculiarities to an exaggerated deposition of stereom, such as is observed also among the contemporary Brachiopods, Lamellibranchs, and Gastropods; 3. that if the granulation of their surface were rubbed down by external, mechanical agencies, they would agree with BRAUN's diagnosis of the Cassian *C. scrobiculata*.

The first argument would be a reasonable one if the Cassian forms alone were considered; but in the Pachycardientuffe the radioles in question are quite numerous. It should also be remembered that other distinct and universally accepted species among the St. Cassian radioles are equally rare.

The second statement is perfectly true if the Pachycardientuffe radioles be compared with the Cassian *C. scrobiculata;* but when the true *C. dorsata* is in question, then the kind of change invoked by Dr. BROILI is admirably seen in the Raiblian mutation *marginata,* and this has not the character of *C. scrobiculata.*

The third argument loses its force when one recognizes that the granulation was developed in the Cassian *C. scrobiculata.* No amount of weathering will turn an undoubted *C. dorsata* into *C. scrobiculata* or *vice versa,* and the very different nature of their ornament is clearly shown by the enlarged figures given herewith (Pl. XI, figs. 317, 334, 337—339).

The radioles of *C. scrobiculata* not only present the slight mutation from the Cassian to the Pachycardientuffe type, but in each set they have varying shapes probably correlated with their position on the test, the pyriform ones being presumably adoral, and the truncate ones adapical.

In all respects then the radioles to which the name *C. scrobiculata* has been applied present sets or series parallel to those of *C. dorsata,* and at no point do I recognise a clear transition from one supposed species to the other.

Material from Bakony. — A single ill-preserved radiole from the Cassian bed *e* of Section VI at Veszprém (fig. 336).

This fragment, which consists of the shaft only, is 4·2 mm. long, with a mean diameter in its thickest part of 3 mm. The shape is pyriform, tending to globose, and the surface, though worn, shows distinct traces of the characteristic pits, especially in the distal region.

«*Cidaris*» *fustis.*

(Plate XII, figs. 34C, 341.)

1865. *Cidaris fustis* G. C. LAUBE, Denkschr. Akad. Wiss. Wien, Math.-Naturw. Cl., XXIV, Abth. 2, p. 290, pl. x, f. 4, 4*a*.

1875. *Cidaris fustis* LAUBE, A QUENSTEDT: Petrefactenk. Deutschlands, p. 198, pl. lxviii, ff. 92—95.

LAUBE's diagnosis is: Radiolus cylindricus, facies undique glabra, collis brevis, fossa articularis parva, glabra.

Discussion of Cassian specimens. — This species is very doubtful. It is exceedingly rare, and such few specimens as have been referred to it are ill preserved. In the collection of the Geological Survey at Vienna are a few fragments, including the holotype. The KLIPSTEIN Collection in the British Museum does not contain a single fragment, unless it be the originals of *C. Meyeri,* a supposition which would of course make *C. fustis* a synonym of *C. Meyeri.* LAUBE's holotype is much rolled, also bored, so that the «facies glabra» may be accidental. Further the surface is not quite «undique glabra», since towards the collerette it shows more signs of longitudinal ribbing even than indicated in LAUBE's fig. 4*a*. Neither should the radiole be described as cylindrical, since it is somewhat bilaterally compressed, having in the proximal half four flattened faces, two on the back and two on the front. At the distal end is a great excavation towards one side, and this suggests that there was a large axial canal. The same feature is shown in QUENSTEDT's figures.

The general shape, the small base, and the longitudinal ribbing of the holotype, remind one of the specimen hereinafter described as *C. Meyeri;* but all LAUBE's specimens of *C. fustis* are thicker in proportion, and their axial canal appears to have been bigger.

Quenstedt has pointed out the distinctions from the somewhat similar *C. Bronni* Klipst.

Hesse (1900, p. 230) places *C. fustis* next after *C. dorsata*. Some specimens of the latter do in fact resemble *C. fustis* in the shape of the shaft and apparently in the loose structure, if not entire absence, of the axial complex; it would be hard to distinguish rolled radioles of this form from *C. fustis*, except by the smaller base of the latter, and this again might be an individual abnormality.

Though I cannot rid myself of the suspicion that the radioles assigned to *C. fustis* may belong, some of them, to *C. Meyeri*, which is itself insecurely established, and the rest to *C. dorsata*, still for the sake of convenience I retain the name for those few cucumber-shaped radioles with small bases, which cannot be referred elsewhere with certainty.

Material from Bakony. — From the Cassian bed *e* 4 at Section VI, Veszprém, comes the proximal portion of a radiole, 4·7 mm. long, sub-cylindrical at its distal end with a diameter circa 1·4 mm., and swollen proximally to a diameter 2·2 mm., while the collar has a mean diameter of 0·6 mm.

From the Raiblian of Jeruzsálemhegy there are four obscure radioles, of which at least one is reminiscent of the holotype, even in accidental features (Pl. XII, figs. 340, 341); it is 21·3 mm. long, with diameters at the widest part 6 mm. and 7·2 mm.; the base is broken off at the collerette, where the diameters are 2 mm. and 0·95 mm.

A subcylindrical radiole, slightly crushed along the middle line, from the Pachycardientuffe of the Tschapit-bach, has been doubtfully referred to this species by Broili (1904, pl. xvii, f. 55), so that the record from the Raiblian is not altogether new.

«*Cidaris*» *decorata*.

(Plate XII, fig. 342, and Plate XV, fig. 442.)

1841. *Cidaris decorata* Münster, Beitr. z. Petrefactenk. IV, p. 45. pl. iii, f. 22 *a, b, c*.
1865. *Cidaris decorata* Münster, G. C. Laube, Denkschr. Akad. Wiss. Wien, Math.-Naturw. Cl. XXIV, Abth. 2, p. 290, pl. x, f. 5 *a, b, e* (not *c, d, f*).
1900. *Cidaris decorata* Münster, E. Hesse, Neues Jahrb. f. Min., Beil.-Bd. XIII, p. 227.
1904. *Cidaris decorata* Münster, F. Broili, Palaeontographica. L, p. 155, pl. xvii, ff. 30—36.

Diagnosis. — A Cidaroid of which the primary radioles have a microstructure of normal *Cidaris* type; shape elongate sub-claviform, pointed distally, often somewhat dorso-ventrally compressed; ornament of sharply raised rounded ribs, some running the whole length of the shaft, others between them shorter, both ribs and intervals with a fine granular longitudinal striation; acetabulum coarsely crenelate; annulus finely crenelate or smooth; collerette tapering from annulus to base of shaft, granulo-striate.

Notes on Cassian specimens. — In a shaft from the Klipstein Collection in the British Museum, with greatest diameter 7·2 mm., are 25 ribs, of which eleven reach the distal end, or, more precisely, come within 1 mm. of the extremity. The longitudinal striae between them are about 28 to the millimetre, but on the ribs they are coarser. These striae, which represent the edges of the radiate septa of the stereom, are broken up into granules, which vary in intensity. Laube describes them as punctate («dunktirte» sic); but the punctate appearance arises only when the ornament is worn, so that one sees the trabeculae uniting the radiate septa, and the «punctae» between them.

The originals of Laube's figs. 5 *c, d, e* do not seem to be of this species. Their outline is different, since they suddenly swell out; also the numerous pustules and spinelets following the course of the ribs are much stronger than the almost microscopic granules of the normal *C. decorata.*

In a few well-preserved radioles of *C. decorata,* however, the granulation assumes a shagreen character coarser than the striation. It then forms a distinct cortical layer, covering the radiate septa. Both the shagreen cortex and the septa exposed where it is eroded are clearly seen in two fragments from St. Cassian (Brit. Mus., E 1024).

The micro-structure is shown in a section of a similar fragment (Brit. Mus., E 4607; Pl. XV, fig. 442). The cortex is here seen to be formed by the suddenly widened and closely abutting outer ends of the radiate septa. It does not form a layer so distinct in structure as in some later Cidaridae, and its thickness is therefore indefinite, but may be taken as from 0·1 to 0·2 mm. The layer of radiate septa is about 0·9 mm. thick. The septa are wedge-shaped, increasing somewhat more rapidly in thickness towards the periphery. They are slightly grouped in fan-shaped fascicles under the ribs, and may dichotomise occasionally near their origin. They start from a thin layer of fine irregular meshes. Within this is the axial complex of much larger, very irregular meshes, which seem to become rather smaller towards the centre. Probably there was irregular resorption about the axis of the radiole, so that in some specimens there seems to have been a large axial canal, now rendered visible by the coloured matrix, while other specimens show no trace of this. In the section described it is hard to see whether there is any axial stereom or not. From the centre outwards, the thickness of the axial complex is about 1·47 mm.

Therefore in a transverse section of a radiole of diameter 100, the relative thicknesses are cortex 3, septal layer 18, total diameter of axial complex 58.

Specimens from the Pachycardientuffe of the Seiser Alp do not markedly differ from the St. Cassian radioles. Those available (Brit. Mus, E 4614 and E 4696) incline to be relatively thinner, and with the dorso-ventral differentiation more marked owing to the absence of ribs on one face (? the adoral); several, rather small specimens, are figured by Broili.

Material from Bakony. — The Cassian beds of Cserhát (Leitnerhof) have yielded a few, generally weathered fragments, which may belong to this species, though it is hard to distinguish them from fragments that probably belong to *Cidaris fasciculata.* Unfortunately microsections showed no structure. The distal end of a radiole, probably of *C. decorata,* has been found in bed *e* 4 at Section VI, Veszprém.

From the Raiblian beds of Jeruzsálemhegy comes the distal end of a radiole, 7 × 1·5 mm., with six ribs (fig. 342). In this fragment longitudinal striae are seen in the intervals between the ribs, and the characteristic micro-structure can be made out on the broken proximal end. The striae are finer than in normal Cassian specimens, being about 35 to the millimetre. This greater fineness of striation has also been noticed in the specimens from the Pachycardientuffe.

«*Cidaris*» *fasciculata.*

(Plate XII, fig. 343.)

1843. *Cidaris fasciculata* A. v. KLIPSTEIN, Geol. Östlich. Alpen, p. 269, pl. xviii, f. 3 *a*—*c*, and 7.
1855. *Cidaris avena* DESOR, Synops. Ech. foss., p. 21, pl. ii, f. 25.
1855. *Cidaris fasciculata* KLIPSTEIN pars, DESOR, Synops. Ech. foss., p. 21, pl. ii, f. 16.
1865. *Cidaris fasciculata* KLIPSTEIN, G. C. LAUBE, Denkschr. Akad. Wiss. Wien, Math.-Naturw. Cl. XXIV. Abth. 2, p. 293, pl. x, f. 12.

Diagnosis. — A Cidaroid with primary radioles subcylindrical or fusiform, the supposed peripheral ones ending in an irregular obtuse point often with marked ribs which die away into the shaft, where they give place to fine longitudinal ribs broken up into granules; collerette varies in relative length, with surface finely striate, sides usually concave, ending in a raised distal margin which is usually oblique; annulus well-marked, striate, almost straight; acetabulum wide, deep, with raised, crenelate margin.

Notes on Cassian specimens. — The diagnosis is based on the eight specimens (syntypes) forming No. 651 of the KLIPSTEIN Collection in the British Museum. Of these I hereby select the original of KLIPSTEIN's pl. xviii, f. 3 *a*, *b*, as holotype (regd. E 9412); the original of f. 3, *c*. is registered E 9413; the original of f. 7 is the holotype of *Cidaris avena* DESOR (regd. E 4682); the remaining five specimens are registered 36495.

In restoring *C. avena* to *C. fasciculata* LAUBE was undoubtedly correct, but it is not clear why he stigmatised KLIPSTEIN's figure 7 as «sehr ungenaue». It is true that the specimen now consists of only the distal half, but this agrees closely with the figure, and there is no reason to doubt the accuracy of the remaining half. Other specimens of *C. fasciculata* have a collerette and base of similar character. KLIPSTEIN's figure 7 represents the specimen from the side of one of the three ribs or keels to which it owes its subtriangular section.

There is little to add to KLIPSTEIN's excellent description of his species, but a few measurements (in millimetres) will render it more precise.

	Holotype	E 9413	36495 *a*	36495 *b*
Greatest length	19·6	11·3	ca 16·5	9·4
Greatest diameter	4·6	2·9	5·4	3·9
Greatest length of collerette	2·8	2·5	2·0	ca 1·6
Least » »	2·2	1·7	ca 1·0	1·0
Least diameter of collerette	3·0	2·0	2·7	2·2
Diameter at annulus	3·2	2·0	?	2·2
Outer diameter of acetabulum	2·5	1·35	?	1·5

These measurements show that there is considerable variation in the relative thickness of the shaft, and in the relative length of the collerette.

The ribs of the shaft run 3 to a millimetre on the side of the least length of collerette, and from rather less than this down to 2 to a millimetre on the other side of the shaft. I cannot decide which face is to be regarded as adoral. These ribs are very much coarser than the striae of the collerette, and are homologous with the ribs of *C. decorata*. In fact, where the surface is worn the striae are seen on the shaft also, about 8 or 9 going to a rib.

The fragments figured by LAUBE as *C. decorata* (his pl. x, f. 5 *c, d, f*) probably belong to this species.

The rarity of *C. fasciculata*, to which species apparently no other author has referred. when taken with the peculiar shape of the collerette, suggests that these radioles may be forms occupying a restricted region of the test in some species of which other radioles have been described under another name. The form, however, is distinct and easily recognised.

Material from Bakony. — There is nothing that can be referred with certainty to *C. fasciculata*, but there are fragments that might as well belong to it as to anything else, while some of the fragments from the Cassian of Cserhát, already mentioned under *C. decorata*, may perhaps represent a species or subspecies, intermediate between *C. decorata* and *C. fasciculata*. Better specimens may be found any day, and in that event the preceding notes may prove useful.

The Raiblian beds *a—b* of Section IV, Veszprém have yielded one fragment of a shaft that is much compressed but presents the ornament characteristic of this species (fig. 343). Length, 6 mm.; transverse diameter, proximal 1·5 mm.; distal 2·3 mm.; dorsoventral diameter, proximal 0·8 mm, distal 1·2 mm.; number of ribs, 8 on one face, 10 rather finer on the other. This specimen may belong to *Cidaris decoratissima*, but the ornament is finer, and the shape of the fragment more reminiscent of some *C. fasciculata*.

«*Cidaris*» *similis.*

(Plate XII, fig. 346, & Plate XV, fig. 444.)

1841. *Cidaris baculifera* AG., MÜNSTER: Beitr. z. Petrefactenk. IV, p. 46, pl. iii, f. 24 *a—c* (non *C. bacculifera* L. J. R. AGASSIZ, 1840: Ech. Foss. Suisse, Mem. Soc. Helvet. IV, p. 80, pl. xxia, f. 12. A Kimmeridgian species).

1843. ? *Cidaris bispinosa* A. v. KLIPSTEIN: Geol. Östl. Alpen, p. 272, pl. xviii, f. 12 *a, b*. (non *C. bispinosa* Defrance, 1817. Made synonym of *C. Wissmanni* DESOR by LAUBE, 1865 and BROILI, 1904).

1846. *Cidaris Braunii* DESOR var. *C. baculifera* MÜNST., AGASSIZ & DESOR: «Catal. raisonn. Ech.» Ann. Sci. Nat. (3), Zool. VI, p. 335. Also separate issue, 1847, p. 31. (non *C. Braunii* DESOR; vide sub *C. Waechteri*).

1849. ? *Cidaris subbispinosa* A. C. D. D'ORBIGNY, Prodr. Pal. stratigr. I. p. 205. (Replaces *C. bispinosa* KLIPST)

1855. *Cidaris similis* E. DESOR: Synops. Ech. Foss. p. 22, pl. ii, f. 28 (reproduces MÜNSTER's f. 24 *a, b*. «Peut-être . . . une variété grèle du *C. Braunii*»).

1855. ? *Cidaris bispinosa* KLIPSTEIN, E. DESOR: Synops. Ech. Foss. p. 22, pl. ii, f. 18.

1863. *Radiolus similis* DESOR, H. E. BEYRICH: Monatsber. preuss. Akad. Wiss. Berlin, Jahr 1862, p. 31. (a specimen from Füssen, like MÜNSTER's f. 24 *a*.)

1865. *Cidaris Braunii* DESOR, G. C. LAUBE; Denkschr. Akad. Wiss. Wien, Math.-Naturwiss. Cl. XXIV, Abth. 2, p. 293, pl. x, f. 6 *e, f*. (non 6 *a—d*, which really are «*C. Braunii*».)

1900. *Cidaris similis* DESOR, E. K. HESSE: N. Jahrb. f. Min., Beil.-Bd. XIII, p. 227.

1904. ? *Cidaris Brauni* DESOR, BROILI: Palaeontographica, L, p. 155 (pars, ? pl. xvii, f. 27).

Diagnosis. — A Cidaroid in which the primary radioles have a microstructure of fine, close-set, wavy, dichotomising and anastomosing septa, with small axial complex; in which normal (peripheral) radioles are baculiform, with shaft dorsoventrally compressed, longitudinally striate, and ornamented with regular longitudinal rows of strong, discrete, subequal pustules, usually thorn-like, more pronounced on one (? adapical) side; collerette distinct, striate; annulus sharp, prominent, striate; acetabular margin prominent, smooth.

The Holotype must be one of the specimens shown in the figures reproduced by Desor, and I therefore select the original of Münster's f. 24 *b*, since it shows the base. It comes from St. Cassian, and is preserved in the Palaeontological Museum, Munich.

Notes on St. Cassian material. — No complete radiole was known to Münster, and none is known to me. The longest fragment in the British Museum (Klipstein Collection) measures 18·5 mm., with a greatest transverse diameter of 2·4 mm. including the pustules, and a greatest sagittal diameter of 2·1 mm. It is the proximal end of a radiole, and the greatest thickness is at about two-thirds of its length. The diameter of the annulus is 1·9 mm.; the outer diameter of the acetabulum, 1·2 mm. The distal end of a radiole in the same collection has a length of 10 mm., and tapers from 1·7 to 0·6 mm. in transverse diameter, from 1·5 to 1·0 mm. in sagittal diameter; the actual extremity was broken off apparently during life, and the broken edges rounded and slightly thickened. Calculation from these data gives 35 mm. as the minimum length admissible for the former fragment. Fragments having, as a few have, a transverse diameter of 3 mm., may therefore have come from radioles at least 44 mm. long. Münster's restoration seems to suggest a radiole rather longer than this. The majority, no doubt, were smaller. The small size of the acetabulum implies a small mamelon, and probably a small test.

The regularity of the ridges is a conspicuous feature. Münster gives their number as from 8 to 10. The first specimen measured above has 8 ridges and a broad smooth back. A narrower proximal fragment has 5 ridges, with an incipient sixth. The largest proximal fragment and the distal fragment previously mentioned have each 7 ridges with an eighth obsolescent or incipient. The number 10 seems to be rare and confined to such radioles as have ridges on the back.

The pustules usually form spinelets with a rake distalwards. The longest proximal fragment has 19 in one of its lateral rows, occupying 15.5 mm. of the shaft. The lateral rows are generally the more complete and regular, and their pustules have a slight dorso-ventral compression; the intervening rows on the supposed adapical face are more pronounced but less regular.

Between the rows and on the frequently smooth back (? adoral face) is seen a very fine longitudinal striation, due to the outcropping radiate septa. The trabeculae are also clearly seen.

The striae of the collerette are rather coarser than those of the shaft.

The annulus is, as a rule, cut to a sharp edge by a flat platform on the distal side, and a slope continuous with the conical base on the proximal side.

The micro-structure (Pl. XV, fig. 444) consists of an axial complex, occupying about one-seventh the total diameter; and of radiate septa, very closely set, and joined by obscure trabeculae. These septa constantly diverge, fork, and re-unite, so that all have a peculiar wavy course. Towards the pustules they fan out and fork rapidly, at the same time thickening. The trabeculae seem rather stout near the periphery, but are very irregular; it is very hard to distinguish them at all in the inner parts of the section. Here the septa often seem broken into short isolated blocks, an appearance probably due to their perforation. Near the periphery the septa are about 70 to the millimetre, a measurement that also applies to the surface striae; but on the pustules they swell out to a thickness of only 40 to the millimetre.

In the section figured, the stereom-strands of the axial complex seem chiefly to lie parallel to the transversal plane. This fact, though at present isolated, when considered in connection with the greater persistence of the lateral rows of pustules, suggests a fundamental and primitive bilateral symmetry. Some small elongate radioles, apparently belonging to *C. alata*, are in fact very like some of the more compressed *C. similis*.

The bilateral form is perhaps best retained in such a variety of *C. similis* as that to which KLIPSTEIN (1843) gave the name *C. bispinosa*. This name, being preoccupied by DEFRANCE (1817), was changed to *C. subbispinosa* by A. d'ORBIGNY (1849). The form was retained as an independent species by DESOR (1855), but was made by LAUBE (1865, p. 291) a synonym of *C. Wissmanni*, with the remark that the species was founded «auf ein schlechtes Bruchstück». LAUBE presumably never saw the fragment, which KLIPSTEIN described as «höchst niedliche». LAUBE's action was followed by BROILI (1904, p. 156). The holotype cannot be traced in the British Museum, and, since it was not mentioned in KLIPSTEIN's Ms. list of his collection as sold to the Trustees, it had probably been lost before the collection was received. It is, however, clear from KLIPSTEIN's description that the shaft was dorso-ventrally compressed, with two longitudinal rows of thorn-like pustules on each side, as represented in KLIPSTEIN's f. 12*b* (incorrectly taken by DESOR to show the upper, i. e. adapical, face); and that the flattened faces were covered with a fine, scarcely visible, longitudinal striation. These features agree so much better with *C. similis* than with *C. Wissmanni* that it seems more reasonable to regard *C. bispinosa* as an individual variation of the former species. In the absence of the holotype, however, it is safer to suspend a decisive judgment, especially as that decision would result in the name *Cidaris similis* giving way to *C. subbispinosa*.

An even more markedly bilateral form was found in the Geologische Reichsanstalt, Wien, among a number of radioles labelled *C. Wissmanni*, and has since been presented to the British Museum (E 4700). It is a fragment of shaft 8 mm. long, with diameters 1·9 mm. and 1·2 mm. On one side is a row of 5 pustules, on the other side a row of 3. The rest of the surface is covered with a fine striation.

BROILI (1904) says that *Cidaris similis*, which he regards as only a thin variety of *C. Braunii* (i. e. *Waechteri*), occurs in the Pachycardientuffe of the Seiser Alp. I do not recall the specimens, but his figures 27 and 29 have not the regular appearance characteristic of *C. similis*: the pustules in his f. 27*a* are quite irregular.

In spite of the difficulty in deciding from their external form whether certain radioles should be referred to *C. similis*, *C. Waechteri*, or even to *C. Wissmanni*, it is not so hard to discriminate between the normal Cassian radioles; and the micro-structure observed in specimens referred on general grounds to *C. similis* is so distinct that there can be no doubt of their specific independence. Probably the true *C. similis* did not persist into Raiblian times.

Material from Bakony. — Cserhát (Leitnerhof) yields two proximal ends of radioles. From bed *e* 4 at Section VI, Veszprém, come three fragments, of which one (Pl. XII, fig. 346) retains the base. From bed *g* of the same section comes another fragment; and a small, short shaft is labelled bed *e*.

These fragments are so imperfect that it is impossible to estimate the length of the radioles. The thickest fragment has diameters 2·4 and 1·9 mm.; the thinnest has diameters 1·4 and 1·3 mm. The most compressed fragment, that from bed *g* of Section VI, has diameters 2·15 and 1·4 mm.

The short shaft from Section VI, bed *e*, is 3·6 mm. long, has a proximal diameter of 1 mm., and a distal one of 1·6, whence it is rapidly rounded off. It may be an adapical radiole of this species.

Neither in their measurements nor in other respects do the larger fragments from Bakony differ appreciably from specimens found at the type-locality. Nevertheless I must admit that had they come from a Raiblian horizon I should not have known how to distinguish them from *Cidaris parastadifera*. This implies, not that the latter species is a synonym of *C. similis*, but that it can only be distinguished from it when the specimens are well preserved and especially when the determination can be checked by examination of the micro-structure.

«*Cidaris*» *Waechteri*.

(Plate XII, figs. 347—351, and Plate XV, fig. 443.)

1841. *Cidaris Waechteri* H. L. WISSMANN in MÜNSTER: Beitr. z. Petrefactenk. IV, p. 48, pl. v, f. 22. (non H. L. WISSMANN MS. quoted by MÜNSTER as syn. of *C. alata*, op. cit. p. 47.)

1841. *Cidaris catenifera* AG., MÜNSTER: Beitr. z. Petrefactenk. IV, p. 45, p. iii, f. 23, *a*, *b*. (non L. J. R. AGASSIZ, 1840: «Ech. foss. Suisse», Mem. Soc. Helvet. IV, p. 79, pl. xxi *a*, f. 23.)

1843. ? *Cidaris spinulosa*[1] A. v. KLIPSTEIN: Geol. Östlich. Alpen. p. 271, pl. xviii, f. 10. *d*, *e*. (non *a*, *b*, *c*, *f*).

1846. *Cidaris Waechteri* WISSM. in MÜNST., AGASSIZ & DESOR: «Catal. raisonn. Ech.» Ann. Sci. Nat. (3), Zool. VI, p. 331, also separate issue 1847, p. 27.

1846. *Cidaris Braunii* E. DESOR in AGASSIZ & DESOR: «Catal. raisonn. Ech.», Ann. Sci. Nat. (3), Zool. VI, p. 335, also separate issue 1847, p. 31 (based on *C. catenifera* MÜNST. non AG., and includes var. *C. baculifera* MÜNST.) [this last excluded in 1855, *v. infra*].

1855. *Cidaris Waechteri* WISSM. in MÜNST.; E. DESOR: Synops. Ech. foss., p. 22, pl. ii, f. 27.

1855. *Cidaris Braunii* DESOR, E. DESOR: Synops. Ech. foss., p. 21, pl. ii, f. 33. (*C. baculifera* MÜNST. here becomes a new species, *C. similis*).

1855. *Cidaris Braunii* DESOR, J. KOECHLIN-SCHLUMBERGER: Bull. Soc. Geol. France (2), XII, p. 1060 (includes *C. baculifera* MÜNST. et *catenifera* MÜNST.).

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[1] *Cidaris spinulosa* KLIPSTEIN (1843, p. 271, pl. xviii, f. 10 *a*—*f*) was based on three radioles, said to come from the Cassian beds of St. Cassian, and now in the British Museum, namely E 4602, f. 10 *a*, *b*, *c*; E 4603, f. 10 *d*, *e*; E 4604, f. 10 *f*. The name was changed by A. D'ORBIGNY (1849. Prodr. Pal. Stratigr., I, p. 205) to *C. subspinulosa*, because AGASSIZ had diagnosed a *C. spinulosa* in 1846 (in AGASSIZ & DESOR, Catal. raisonn. p. 330). This was no good reason, but since the name *Cidarites spinulosus* was used in 1835 by F. A. ROEMER (Norddeutsch. Kreidegeb. p. 26), D'ORBIGNY's action was legitimate. Neither KLIPSTEIN nor D'ORBIGNY selected a holotype. DESOR (1855, Synops. Ech. Foss. p. 21, pl. ii. f. 15), ignoring D'ORBIGNY, changed the name to *C. perplexa* and reproduced KLIPSTEIN's f. 10 *a*, *b*. Specimen E 4602 (Plate XII, figs. 344, 345) may therefore be regarded as the holotype of *C. perplexa*. To save future confusion, I make the same specimen lectotype of *C. spinulosa* KLIPST. and of *C. subspinulosa*. Thus the three names become absolutely synonymous, and if any one of them is to be used it must be *C. subspinulosa*.

On the evidence of KLIPSTEIN's figures and description the lectotype of *C. subspinulosa* has been referred by LAUBE (1865, p. 289) and by BROILI (1904, p. 157) to *C. semicostata*. Examination

1865. *Cidaris Braunii* Desor, G. C. Laube: Denkschr. Akad. Wiss. Wien, Math.-Naturwiss. Cl. XXIV, Abth. 2, p. 293, pl. x, f. 6 *a—d* (non f. 6 *e, f*). (Includes *C. catenifera* Münst., *C. baculifera* Münst., *C. Waechteri* Wissm., *C. similis* Desor).

1875. *Cidaris Waechteri* Wissm. in Münst., F. A. Quenstedt: Petrefactenk. Deutschlands, III, p. 205, pl. lxviii, f. 131.

1900. *Cidaris Braunii* Desor, E. K. Hesse: N. Jahrb. f. Min., Beil.-Bd. XIII, p. 229.

1904. *Cidaris Brauni* Desor, F. Broili: Palaeontographica, L, p. 155, pl. xvii, f. 27—29. (Corresponds to both *C. Waechteri* and *C. similis*, but seems a slight mutation from the Cassian type. Vide supra sub *C. similis*).

Diagnosis. — A Cidaroid in which the primary radioles have a microstructure of coarse meshes, dominated by a radiate arrangement, merging adcentrally into an irregular axial complex and a variable, ill-defined lumen, and centrifugally into a finer and more regular meshwork with dichotomous radiate septa; in which normal peripheral radioles are straight-sided, tapering to base, dorso-ventrally compressed, rounded distally, bearing unequal pustules in irregular longitudinal rows, more developed on supposed adapical face, frequently forming serrate margins, and usually reduced to granules on supposed adoral face; collerette distinct, short, finely striate; annulus, rounded, prominent, finely crenelate; acetabular margin prominent, smooth or slightly crenelate. Adapically the radioles tend to be more clavate, less compressed, and less spinulose.

The Holotype has not been definitely fixed; so the original of Wissmann's f. 22 (1841) is hereby selected.

The holotype of the synonym *Cidaris Brauni* is the broken radiole figured by Münster (1841, pl. iii, f. 23) as *C. catenifera* Ag.

Discussion of the St. Cassian specimens. — So far as outward form is concerned, the difference between the two holotypes is almost entirely one of size. The differences that can be gathered from the original descriptions of Wissmann and Münster are: *C. Waechteri*, dorso-ventrally compressed, with projecting serrate margin, acetabular margin smooth; *C. catenifera* (i. e. *Brauni*) clavate, thickest in middle, acetabular margin slightly crenelate. Not much weight can be attached to the last character, which is easily affected by the state of preservation and is often found in normal examples of *C. Waechteri*. It should also be noted that the annulus is crenelate when well preserved, not smooth as stated in the original descriptions. The other differences are consistent with a different position on the test, *C. Brauni* being presumably the more adapical. This is confirmed by Münster's statement that the rounded distal end of his *C. catenifera* bears two small circlets of pustules. This precise feature is doubtless an individual character,

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of the specimen itself shows that it has nothing to do with that supposed species, which I now regard as a form of *C. alata*, but that it most closely resembles several small radioles of *C. Roemeri* Wissm. em. Quenst, (excl. *C. complanata*). It is the slight ribbing of the adoral face that produces a resemblance to *C. semicostata*, but there are no lateral vanes, and the strong V-shaped ridges of the adapical face are characteristic of *C. Roemeri*. *C. subspinulosa*, then, is most probably a synonym of *C. Roemeri*.

Specimen E 4603 (Klipstein's f. 10 *d, e*), which was referred by Laube (1865, p. 287) to *C. Roemeri*, is much more like a small radiole of *C. Waechteri*, but might possibly belong to *C. Wissmanni*.

Specimen E 4604 (Klipstein's f. 10 *f*) was also referred to *C. Roemeri* by Laube (loc. cit.), but it is probably the distal end of a rather abnormal *C. Wissmanni*.

but it suggests an incipient «Endkrone», such as is common in circumapical radioles. A similar feature occasionally noted is the actual excavation of the distal end, but this is also seen in smaller specimens.

There is, no doubt, considerable difference between some of the large, massive, rounded radioles ascribed by MÜNSTER, KLIPSTEIN, and such old authors to *C. catenifera*, and the smaller, flattened radioles agreeing with the holotype of *C. Waechteri*. The radioles are rarely complete, but estimates based on the larger fragments in the British Museum (36518, 36519) give measurements 66 mm. × 11·4 mm. and 75 mm. × 16·4 mm. MÜNSTER's reconstituted fragments (f. 23) give 59 mm. × 10 mm. The figure of the complete holotype of *C. Waechteri* measures 28·3 mm. × 5·8 mm. A complete radiole labelled *C. Waechteri* by KLIPSTEIN (Brit. Mus., E 4608) measures 23·8 mm. × 4·8 mm. Between these extremes of size, however, there is every possible gradation.

There is also a marked contrast between the rounded ends with diameters 16.4 & 15·7 mm. and 9·8 & 9·0 mm., such as characterise the larger radioles, and the flattened section found in some typical *C. Waechteri*. It may, however, be observed that the extreme flattening is due to crushing, and that the dorso-ventral compression is less marked at the distal end, which is in fact rounded, as described by WISSMANN; thus, an uncrushed shaft (Brit. Mus. 75862) has at the middle of its length the diameters 5·3 & 3·9 mm., and near its distal end 5·5 & 4·5 mm. Taking the greater diameter as 100, the ratios of the shorter diameter are, for the larger radioles, about 95 and 91, and for the smaller radioles about 81.

So far then as outward form is concerned, the differentiae of the largest radioles seem to be the more cylindrical shaft, the more equal distribution of pustules on its two faces, the diminution in size and number of the pustules, especially near its distal end, and the absence of a serrate margin. The number of radioles presenting these extreme characters is relatively few. The holotype of *C. Brauni* itself scarcely shows them. Many radioles presenting all the characters of the holotype of *C. Waechteri* reach the larger size, so that there is a complete series of gradations in every respect.

Acting presumably on some such considerations as those just given in detail, LAUBE and a few others have merged the two forms of MÜNSTER and WISSMANN in a single species, which they have as a rule called *Cidaris Brauni*. In this, however, they have also included *Cidaris similis*, which, as shown above, is entitled to independence. HESSE (1900, p. 230) while eliminating *C. similis* on the ground of its distinct micro-structure, has stated that *C. Brauni* and *C. Waechteri* completely agree in their micro-structure, and has therefore united them under the name *C. Brauni*. As to the facts I can confirm the observations of HESSE, but must point out that the name *Cidaris Waechteri* WISSMANN (1841) is incontestably prior to *Cidaris Brauni* DESOR (1846).

The micro-structure has been studied in cross-sections of two radioles from St. Cassian closely agreeing with the original *C. catenifera* MÜNST. and *C. Waechteri* WISSM. The illustration (Pl. XV, fig. 443) represents the structure of the former; but it so closely resembles the structure in the latter that a separate figure seemed quite unnecessary. As described by HESSE (1900, p. 229) the radiate septa have lost their straightness, are wide apart, and united by long trabeculae so as to form a coarse network, which, though irregular, is still governed by the radiate structure.

To this brief statement may be added the following. The limits of the axial complex are not clearly defined, but it seems to merge into an axial lumen, probably of variable size. The presence of a definite lumen is proved macroscopically by the crushing of so many of the flatter radioles, and microscopically by the occurrence of fragments of other fossils in the central area of the section not here figured. The meshes immediately surrounding the lumen have very fine walls and are quite irregular, but become more radiate in arrangement further from the centre. All these larger meshes are here somewhat arbitrarily assigned to the axial complex and give it a diameter of two-fifths that of the radiole. They are succeeded by a band of much finer meshes, half their size or less. These latter, however, are soon followed by larger meshes, arranged in radiating irregular rows. In the other section — across the smaller and more flattened radiole — these meshes appear more centrifugally elongate, an appearance possibly due to the destruction of some trabeculae. At a short distance from the periphery, equal to about 0·65 of the total diameter, the meshes become smaller and the walls between them so definitely arranged as to constitute distinct radiate septa with approximately equidistant trabeculae. In a more regular meshwork this would have implied considerable dichotomy of the septa during the inner part of their course, but here dichotomy cannot be distinguished except in this outer layer. The number of septa cropping out on the surface is about 23 to a millimetre. In the inner layer where the meshes are largest, there are about 13 to a millimetre.

This micro-structure, which, according to Hesse (1900, p. 229) «am weitesten vom normalen *Cidaris*-Typus entfernt sich», is only an exaggeration of the micro-structure seen in *C. Wissmanni* (Pl. XV, fig. 445), where, on the same authority (p. 227) «das mikroskopische Bild des normalen *Cidaris*-Typus bis ins Kleinste und in grösster Schärfe ausgeprägt». The difference lies in the greater coarseness of mesh throughout, and more particularly in the greater coarseness and irregularity of the layer next to the axial complex. The micro-structure of *C. similis* is far more distinctive, and it is curious that the species usually confused with *C. Waechteri* (= *Brauni*) should be not *C. Wissmanni*, which really presents a strong likeness, but the more remote *C. similis*.

In view of the comparison made by Münster of *C. Waechteri* to *C. alata*, it may be noted that in micro-structure the former is nearer *C. dorsata*.

Material from Bakony. — The scarcity of the species is remarkable. The Cassian beds of Cserhát (Leitnerhof) have yielded only three specimens, and three insignificant fragments come from the Cassian bed *e* 4 of Section VI, Veszprém.

These specimens all indicate smaller radioles than those common at St. Cassian. The only perfect one among them is the smallest (Pl. XII, figs. 347, 348). Length, 7·2 mm. Greatest diameter: transverse, 1·5 mm.; sagittal, 1·15 mm. Diameter at annulus, 0·8 mm. It has serrate margins, and on each face three rows of pustules, making 8 rows in all. The distinction between the faces is slight, but the supposed adapical face may be identified by the proximal curvature in that direction of the lateral lines of pustules, as in *C. alata*. The annulus is not very distinct, but appears to slant towards the proximal end and adoral face.

Of the larger fragments from Cserhát, one comes from the proximal region, the other from the distal. That from the proximal region (Pl. 350, figs. 351) is slightly the thinner and is more compressed, its diameters being 3·8 and 3·0 mm.

In addition to the lateral ridges, which are not very distinct, there are 6 rows of fine pustules on the adoral face, and three or four rows of coarse pustules on the adapical face. The distal fragment (Pl. XII, fig. 349) has greatest diameters 4·9 mm. and 4·7 mm., and tapers rather gradually to the extremity. The difference between the adoral and adapical faces can just be detected, though the lateral ridges can not be distinguished. In the stoutest part are about 18 ridges with ill-defined pustules, and between these ridges are occasionally other lines of pustules.

The fragment last described, in the coalescence of certain pustules to form ridges, reminds one of some of the specimens doubtfully referred to *C. decorata*. The same is the case with the three fragments from Section VI. Perhaps there was in Bakony a distinct form with pustulate ribs; but whether it should be regarded as local variety of *C. Waechteri* or of *C. decorata* cannot be decided without more material and better micro-sections.

The Raiblian beds of Bakony have furnished no specimen clearly belonging to this species. Wöhrmann (1889, p. 194) quotes the species as *C. Brauni* from the Cardita-Oolith of «Erlsattel bei Zirl, Rammelsbach und Kienberg bei Seehaus». The fragment of shaft from Kienberg (his pl. v, f. 13) closely resembles *C. similis*, a species included by Wöhrmann in *C. Brauni;* probably it belongs to *C. parastadifera*. The other fragments, including that from Rammelsbach said to be figured (pl. v, f. 14), are most obscure. and while I compliment my friend on his vision I am disinclined to include *C. Waechteri* among Raiblian species on such doubtful evidence. I have already (p. 180) suggested that they may be *C. dorsata marginata* or *C. alata poculiformis*.

«*Cidaris*» *Wissmanni*.

(Plate XII, figs. 352—358 & Plate XV, fig. 445.)

1841. *Cidaris spinosa* Ag., Münster: Beitr. z. Petrefactenk. IV, p. 44, pl. iii, f. 16 (non L. J. R. Agassiz, 1840: «Ech. foss. Suisse». Mem. Soc. Helvet. IV, p. 71, pl. xxi *a*, f. 1).
1846. *Cidaris Wissmanni* Desor in Agassiz & Desor: «Catal. raisonn. Ech.», Ann. Sci. Nat. (3) Zool. VI, p. 330, also separate issue p. 26. (Based on the preceding.)
1855. *Cidaris Wissmanni* Desor, E. Desor: Synops. Ech. foss. p. 22, pl. ii, f. 19.
1865. *Cidaris Wissmanni* Desor, G. C. Laube, Denkschr. Akad. Wiss., Wien, Math.-Nat. Cl. XXIV, Abth. 2, p. 291, pl. x, f. 8 (includes *C. bispinosa* Klipst., see p. —).
1900. *Cidaris Wissmanni* Desor, E. K. Hesse, N. Jahrb. f. Min., Beil.-Bd. XIII, p. 227.
1904. *Cidaris Wissmanni* Desor, F. Broili: «Pachycardientuffe d. Seiser Alp», Palaeontogr. L, p. 156, pl. xvii, f. 49 (includes *C. bispinosa* Klipst.).

Diagnosis. — A Cidaroid in which the primary radioles have a microstructure of fine, distinct, slightly wavy and dichotomising septa, joined by distinct trabeculae, forming meshes larger towards the axis, where they merge in a relatively large axial complex; in which normal (peripheral) radioles are baculiform, striate faintly and irregularly or not at all, and ornamented with irregular longitudinal rows of pustules set at irregular intervals, varying in size from granules to thorns, and often reduced on one face of the shaft; collerette short, striate; annulus rounded, not very prominent, finely crenelate when well preserved; acetabular margin crenelate.

The Holotype is the original of Münster's pl. iii, f. 16, since it was on this alone that DESOR founded his species. It is part of a shaft from St. Cassian, and is preserved in the Palaeontological Museum, Munich.

N o t e s o n C a s s i a n m a t e r i a l. — Specimens closely resembling the holotype, though not abundant, are to be found in all the larger collections. Five fragments, of which one has recently been used for a transverse micro-section, were labelled «*Cidaris spinosa* M.» in the KLIPSTEIN Collection of the British Museum (regd. 36487). Characteristic specimens were found associated with *C. similis* in the Geologische Reichsanstalt, Wien, and labelled *C. Wissmanni*. Similar confusion of these two forms obtained in the British Museum and in others, but confusion with *C. Waechteri* is no less common.

No complete radioles are known, but LAUBE has supplemented MÜNSTER's account with the figure (pl. x, f. 8 *a, b*) of a proximal portion.

The stoutest fragment in the British Museum (36487) has diameters of 5 and 4·5 mm., including the pustules, or about 4 and 3·5 mm., excluding them. In this specimen the pustules are narrow and longitudinally extended, but not very thornlike. The fragment appears to be distal end of a supra-ambital or circumapical radiole, since it is not markedly bilateral and ends in a depression containing small pustules.

A well-preserved and highly characteristic fragment from the middle of a shaft (E 4700) has diameters 3·4 and 2·6 mm, including the pustules, and about 2·1 and 1·9 mm. excluding them. The pustules of the side and of one (? adapical) face are markedly thorn-like, becoming almost cylindrical at their ends; those of the other (? adoral) face are little more than granules, but are quite distinct. All the pustules have a strong rake distalwards.

The pustules differ from those of *C. similis* in being further apart, not borne by ridges, often far more thornlike, and usually quite irregular in distribution. The last fact renders it difficult to compare the number with that of *C. similis*, but in so far as one can speak of longitudinal rows at all, one can estimate their number at from 7 to 10. In the smaller shafts it is usual for there to be a row of strong thorns down each side and two rows on the supposed adapical face, while on the other face are 3 or 4 rows of granular pustules.

The surface of the shaft between the pustules appears quite smooth in the better preserved examples, but here and there, especially in weathered specimens, the micro-structure of the stereom is obscurely exposed; this appears irregular, even more so than one would expect from a transverse section, and no such clear longitudinal striation as characterises *C. similis* can be detected. On the handle of the shaft, however, the longitudinal striation may be more distinct, as shown in LAUBE's figure 8 *b*. This is confirmed, though not very strongly, by the proximal half of a radiole in the KLIPSTEIN Collection (E 8422). Here the collerette is succeeded by a smooth handle, about 2 mm. long, with distinct striae. The pustules of the shaft, however, are more numerous and more crowded than in the holotype and similar forms, so that the specimen may be more closely allied to *C. Waechteri*.

The collerette in LAUBE's figure 8 *b* is 1 mm. long, tapering distalwards, and more coarsely striated than the shaft. In E 8422 it is relatively shorter and is obscure.

The annulus, in the same figure and specimen, is finely crenelate, and does not project from the collerette to the same extent as in *C. similis*.

The margin of the acetabulum is described and figured by LAUBE as deeply crenelate. In E 8422 there are traces of crenelation.

The micro-structure consists of an axial complex, which, in the cross section studied (Pl. XV, fig. 445), occupies about one-fourth of the total diameter, and is transversely elongate. This is surrounded by a layer of relatively large, irregular meshes, which gradually become smaller and arranged in rows radiating from the centre. The radiate septa are fine, distinct, occasionally dichotomising, so that on the periphery their number is just double that at their commencement, and they are a little closer together. Owing to the dichotomy they wave slightly. The trabeculae also are fine and distinct, enclosing fairly regular, square or elongate meshes. Near the periphery the septa are about 37 to the millimetre, and nearer the centre about 32.

The difference between this micro-structure and that of *C. similis* is remarkable considering the resemblance of outward form.

Except for its far greater regularity and the greater fineness of mesh, the micro-structure rather resembles that of *C. Waechteri*, a species with which *Cidaris Wissmanni* is also liable to be confused (see p. 194). The differences of outer form are chiefly the thin baculiform shape and the distinct thornlike pustules of *C. Wissmanni*, as opposed to the widening and compressed or claviform shape and the smaller often confluent pustules of *C. Waechteri*. There are, however, many specimens that cannot be determined with certainty, at least in the absence of microscopic examination.

Material from Bakony. — The radioles that can with least doubt be referred to this species are all of Cassian age and come from the following localities: Cserhát (Leitnerhof), 40 specimens; Section VI, Veszprém, bed *e*, 1 specimen, bed *e* 4, a doubtful fragment; Veszprém, Giricses-domb, Lower stratified Limestone, 4 specimens. From the same localities come other radioles that may represent one or two varieties of this species, while a third form is found in the Raiblian of Jeruzsálemhegy; to these we shall return.

Even the more normal radioles comprise several different forms. The form most like the holotype is represented by the specimen from Section VI, and by two from Giricses-domb. Of these the first is the proximal end of a flattened radiole, with diameters 2·5 and 1·1 mm., with flattened, almost smooth adoral face, with prominent thorns along each side, and with two or three irregular rows of somewhat thorn-like pustules on the adapical face. Of the two from Giricses-domb, one is a fragment of the shaft, 9·3 mm. long, not flattened, with diameter 2·1 mm., and with slightly thorn-like pustules so irregularly set that longitudinal rows can scarcely be said to exist, but about 8 pustules surround the shaft at any level. The other specimen appears to be the distal end of a shaft, 6 mm. long, very slightly flattened, with diameters at the thicker end 1·6 and 1·45 mm., thence gently tapering to the extremity; its pustules have the general character of those in the preceding specimen. These two specimens show traces of an axial lumen or, it may have been, a very loose axial complex.

Several of the Cserhát specimens are also fairly normal, though it is sometimes difficult, in the absence of micro-sections, to distinguish them from *C. Waechteri*. Some twelve may be separated as thin, with sparse thorn-like pustules (Pl. XII, figs. 353, 354.); their diameters range from 1·1 mm. to 2·7 mm.; some are slightly flattened; their pustules often tend to arrange themselwes in rows, sometimes longitudinal but frequently oblique, and those in a row may be connected by a slight ridge; some show traces of a lumen, others certainly do not, a difference that may depend partly on weathering, partly on the region of the shaft from which each fragment comes. Ten specimens again are rather stouter, more or less cylindrical, with greatest diameters from 2·1 to 2·8 mm., with more numerous pustules, not very thorn-like; in other respects like the preceding lot. The length of the larger among these might be roughly estimated at 25 mm. The next half-dozen specimens appear to be generally similar in character, but have more and smaller pustules, sometimes tending to be grouped in oblique or transverse rows (Pl. XII, fig. 352). One of these is a complete radiole, probably from the circum-apical region; it is 10 mm. long, very slightly flattened, and increases from a diameter of 1·9 at the proximal end of the shaft to one of 3·3 mm., at 1·6 mm. from the distal end, where it terminates in an obtuse, slightly rounded, pustulate point; the fine pustules are arranged in oblique rows, usually from left proximal to right distal, but occasionally so regular as to produce other oblique rows crossing them. In three other almost complete radioles from Cserhát, of the same form as that last described, the pustules are much coarser, and their arrangement in transverse rows so marked, at least on the adapical face, that the shafts resemble those found in some forms of *C. Roemeri* (Pl. XII, fig. 355). If there were other reason to believe in the occurrence of that species in Bakony, the question would arise whether these radioles should not be referred to it; but as things are, it seems preferable to regard them as probably supra-ambital or circumapical radioles of *C. Wissmanni* or perhaps *C. Waechteri*.

There are 9 other specimens from Cserhát, of rather thin, usually cylindrical form, differing from most of the normal radioles above described only in the occurrence of a rather coarse longitudinal striation, or fine ribbing, sometimes breaking up into granules, and frequently accompanied by an elongation of the pustules in the same direction (Pl. XII, figs. 357, 358). It is hard to say whether this is a rugose ornament or a weathering out of the stereom structure; in either case it is of no great systematic importance. This rugose surface is well seen in a fragment of shaft from Giricses-domb, which in other respects closely resembles the normal specimens from that hill.

From the same locality, Giricses-domb, comes a curiously curved thin fragment of shaft, 7·7 mm. long, about 0·8 mm. thick, excluding the pustules, which are small, thornlike, quite irregular, and number only 10 on the whole fragment.

In none of these specimens is the base really well preserved. The acetabular margin still show traces of crenelation in some cases, but the finer crenelation of the annulus is in no case to be detected (Pl. XII, fig. 356).

This completes the account of those radioles from Bakony to which the name *C. Wissmanni* may as a rule be applied without further qualification. They do not differ from the St. Cassian radioles of that species in any marked character except that of size, those of St. Cassian being as a rule much larger.

We pass now to a number of radioles that seem closely related to *C. Wissmanni*, or possibly to *C. Waechteri*, but at the same time constitute a fairly homogeneous and independent group. They most nearly resemble those stouter cylindrical radioles from Cserhát with the less thornlike pustules, which have just been described under *C. Wissmanni;* and for this reason it may be as well to describe them for the present as —

Cidaris Wissmanni var. nov. *rudis.*

(Plate XII, figs. 359—366, & Plate XV, fig. 446.)

Diagnosis. *C. Wissmanni* in which the micro-structure of the primary radioles is finer and less distinct than in the type-form, the meshes of the outer layer not smaller towards the axis; in which the shaft of the peripheral radioles has a diameter (estimated) about 0·14 of the radiole length, and is closely set with pustules very irregular in size and distribution.

Material. — The Cassian beds of Cserhát (Leitnerhof) have yielded 155 fragments, a few of which might prove to be the normal *C. Wissmanni,* or even other species, if it were worth while to clean them all from the closely adherent matrix. Four good fragments come from Giricses-domb, Lower stratified Limestone. Section VI near Veszprém has produced one fragment from bed *e* 4, and 9 very obscure and doubtful fragments labelled bed *e*. From bed *i* of Section XI, Veszprém, come the proximal and distal ends of a radiole, possibly to be placed here. All the preceding seem to represent somewhat elongate radioles, peripheral or infra-ambital. There are also some shorter, rather ovoid radioles, possibly circum-apical, represented by specimens or fragments from Section VI, one labelled bed *e* 4, and 6 labelled bed *e*. Thin transverse sections have been made of three characteristic specimens from Cserhát.

Holotype. -- A radiole from Cserhát (Pl. XII, fig. 359).

A few of the more nearly complete specimens have been selected from the Cserhát material and cleaned so far as possible. The following account is based on these and on the holotype, except where otherwise stated.

Description of Specimens from Bakony. — The most obvious feature of the more cylindrical radioles is the roughness and irregularity of the shaft. Not only are the pustules placed without order, but they vary in size and shape, and frequently a shaft may bear a few prominent pustules and other groups of small ones. The general appearance of roughness is no doubt often due to the adherence of matrix, but this in its turn is probably due to the roughness of the radiole surface, and in some instances the foreign substance may in part be composed of the remains of sponges, hydrozoa and the like, parasitic on the radiole during life. This is notably the case with two specimens from Giricses-domb.

The fragments are too short to enable one to base on them any satisfactory estimate of the length of the radiole. The longest fragment measures 15·9 mm., with a greatest diameter of 3·2 mm.; it is imperfect at each end, and must have come from a radiole at least 23 mm. long. The holotype, in which the base is preserved, is 15.5 mm. long, with a diameter of 2·8 mm., and must have attained a length of at least 20 mm. The diameters include the pustules. These estimates of length are much the same as those of the stouter radioles of *C. Wissmanni* from Cserhát, of which the thickest had a diameter of 2·8 mm. That thickness is often equalled or exceeded in this variety, the greatest diameter noted being 3·9 mm. (fig. 360). Of course there are fairly elongate fragments with diameters less than those above given, e. g. a fragment 6 mm. long from near the distal end of a shaft has a maximum diameter of 1·2 mm. On the whole, however, these radioles are relatively stouter than the more normal *C. Wissmanni* from the same locality.

A distal fragment from Section XI, bed *i* (Pl. XII, fig. 361), has a length of 12·4 mm., and a greatest diameter of 4 mm. Since the pustules are low and smooth, and may therefore have been worn down, the diameter including pustules may have really been even more.

The account of the base in the specimens of *C. Wissmanni* from Bakony applies also to this variety. A rather large and fairly preserved base was found at Section XI, apparently close by the shaft-fragment just described (Pl. XII, fig. 362). It may, therefore, have belonged to it. The annulus, which has a diameter of 2·9 mm., is a somewhat squarely projecting band 0·6 mm. high. It shows no traces of crenelation.

The micro-structure has been studied in sections of two characteristic specimens from Cserhát. These proved to be rather obscure, but the essential features are adequately represented in (Plate XV, fig. 446). The axial complex is of loose composition and may in places break down into a lumen; as in the typical *C. Wissmanni*, it occupies about one fourth of the total diameter and is transversely elongate. The layer of large irregular meshes forming the border of the complex is is not quite so well developed as in the normal form, and passes more suddenly into the outer layer composed of radiating septa. These septa dichotomise at intervals, but not to such an extent as to become closer together near the periphery. With their trabeculae they form a meshwork, which is more irregular than in the normal form and increases in irregularity towards the periphery. Near the periphery the septa are about 44 to the millimetre, and about 50 nearer the centre. The structure is therefore finer than in the normal form where the corresponding numbers are 37 and 32.

Six specimens from Section VI, Veszprém, labelled bed *e*, and one labelled bed *e* 4, seem to represent a short ovoid form of smoother surface, which may have come from the circum-apical region of *C. Wissmanni* or of its var. *rudis*.

That from bed *e* 4, though lacking the proximal end, appears to have had all the characters of var. *rudis* except length and cylindrical shape. Its length is 5·7 mm. (slightly broken since being measured), its diameter increases from 2 to 2·3 mm. and then lessens gradually. The pustules are intermediate between rounded and thornlike, and on one face tend to a transverse arrangement.

Of the fragments labelled bed *e*, two are almost complete, though lacking the actual base. The shorter (Pl. XII, figs. 363, 364) is 5·3 mm. long, slightly flattened, with greatest diameters 2·7 and 3·5 mm.; the diameter of the collerette may be estimated at 1 mm.; the shaft swells out more rapidly than it tapers to the end; on one face the pustules are more prominent than on the other. The other specimen (Pl. XII, figs. 365, 366) is of like character, 7·2 mm. long, with greatest diameters 2·9 and 3·3 mm., and tapering at the end rather more rapidly than does the former specimen; the larger pustules tend to a longitudinal arrangement. Of the other fragments, three are distal ends, tapering rather rapidly, with smooth surface and distinct, often pointed pustules.

This ovoid form is very distinct, but there is at present no reason why it should not belong to *C. Wissmanni.*

«Cidaris» Hausmanni.

1841. *Cidaris Hausmanni* H. L. WISSMANN in MÜNSTER: Beitr z. Petrefactenk. IV, p. 44, pl. iii, f. 14 *a—d*.
1855. *Cidaris Hausmanni* WISSMANN, E. DESOR, Synops. Ech. foss p. 19, pl. ii, f. 2 *a—d*.
1855. *Cidaris Hausmanni* WISSMANN, J. KOECHLIN-SCHLUMBERGER: Bull. Soc. geol. France (2), XII, p. 1064.
1863. *Radiolus Hausmanni* WISSMANN, H. E. BEYRICH: Monatsber. preuss. Akad. Wiss. Berlin, Jahr. 1862, p. 30.
1865. *Cidaris Hausmanni* WISSMANN, G. C LAUBE: Denkschr. Akad. Wiss. Wien, Math.-Nat. Cl. XXIV, Abth. 2, p. 284, pl. ix, f. 13.
1900. *Cidaris Hausmanni* WISSMANN, E. K. HESSE: N. Jahrb. Mineral. Beil.-Bd. XIII, p. 228, f. 1.
1904. *Cidaris Hausmanni* WISSMANN, F. BROILI: Palaeontogr. L, p. 154, pl. xvii, ff. 25, 26.

Diagnosis. — A Cidaroid in which the primary radioles have a microstructure of fine waving septa arranged in fan-like groups, with a general tendency to radiate from the inconspicuous axial complex. Normal radioles vary from globose to thin fusiform, often irregular in shape, but not compressed dorso-ventrally; ornament of longitudinal ribs bearing pustules, which may coalesce and disappear; base oblique to main radiole-axis; collerette short with pronounced distal rim; annulus not prominent, base constricted below it.

Lectotype, the radiole figured in MÜNSTER (1841, pl. iii, f. 14 *b*), from the Cassian beds of St. Cassian, now in the Palaeontological Museum, Munich.

History of the Species. — The type-description by WISSMANN in MÜNSTER (1841, p. 44) gives the following characters: radioles small, of various form, pyriform, fusiform, or claviform, with strong more or less granular ribs; «Stiel» very short; base and annulus smooth.

DESOR (1855) noted the distinction from *C. dorsata* in the seriation of the pustules, and reproduced WISSMANN's figures.

KOECHLIN-SCHLUMBERGER (1855) maintained the species, and pointed out that the acetabular margin and the annulus were always oblique to the main axis.

BEYRICH (1863) described many radioles found on one fragment of rock at Füssen.

LAUBE (1865) added to the characters already mentioned the statement that sometimes, especially in round shafts, there were parallel cross-grooves between the rows of pustules; perhaps he meant that the pustules formed transverse rows as well as longitudinal, an occurrence I have not noticed myself. He also said that the acetabulum was very small with a smooth margin. LAUBE's figures illustrate the variety of form and ornament, the oblique base being almost the only obvious feature they have in common; indeed figures *b* and *c* may possibly represent young *C. alata*.

In this connection it may be mentioned that one of the four radioles figured by KLIPSTEIN (1843, pl. xviii, f. 14 *a—g*) as «Unbestimmte Cidariten» reminds one of *C. Hausmanni*. This specimen (KLIPSTEIN f. 14 *a*, *b*; Brit. Mus. E 4597) has both ornament and base characteristic of that species, the differences being that the shaft is compressed, with one face ribbed rather than pustulate, and that the obliquity of the base is in a direction between the sagittal and transversal planes of the shaft, a position which is, as we shall see, intermediate between that in *C. alata* and in *C. Hausmanni*.

QUENSTEDT (1875, Petref. Deutschl. III, p. 194) referred *C. Hausmanni* to *C. dorsata,* but the radioles figured by him (pl. lxviii, ff. 69—71) do not seem to be the true *C. Hausmanni;* they are larger and have irregular pustules.

HESSE (1900) was the first to place the species on a secure basis by showing that its micro-structure was peculiar; to the details of this we shall return later.

BROILI (1904) stated that the radioles were common in the Pachycardientuffe of the Seiser Alp; but, as will be shown later on, these specimens differ in several respects from the Cassian forms, and are best regarded as a mutation of Lower Raiblian age, for which I propose the name *tofacea.* For the present it will be convenient to exclude this mutation, and to consider more closely the radioles of Cassian age under the name

«Cidaris» Hausmanni typica.

(Pl. XII, figs. 367—369 & Pl. XVI,. figs 448, 449.)

Diagnosis. — *C. Hausmanni* of larger size, the average length being 6 mm.; ridges well-marked and reaching the distal end of the shaft, with intervening grooves about as wide as the ridges, pustules usually distinct and rarely quite obsolete; base markedly oblique to the main radiole-axis.

Lectotype, type-locality, type-description same as for the species.

Description of Specimens from St. Cassian. — From a number of specimens in the British Museum apparently belonging to this species, I have selected eight, which certainly belong to it, for the study of the external form (E 9510—E 9517), and a ninth of similar appearance for the study of the microstructure (E 9518). Specimen E 9515, though not quite complete distally, is figured (Pl. XII, fig. 367), as it shows the ornament and the base very clearly. Measurements in millimetres and other details are given in the following table:

Register Number	E 9510	E 9511	E 9512	E 9513	E 9514	E 9515	E 9516	E 9517
Shape	pyriform	swollen fusiform	swollen fusiform	fusiform	globose	swollen fusiform	pyriform	fusiform
Length	4·5	4·9	5·5	5·9	6·6	7·0	7·3	7·6
Greatest diameter	2·8	2·7 2·4	3·2	2·0 1·9	4·1 3·9	3·2	3·6 3·0	2·7 2·4
Diameter at annulus	1·1	1·0	1·4	1·0	1·6	1·5	1·7	1·2
Number of ribs in a width of 1 mm	3—3·5	2·5—3	2·5—3	2·5—4	2—3	2—3	2—3	2
Number of pustules in a length of 1 mm	4·5	3—5	3—4	3—4	?	3—3·5	3—4	3—4

The shapes compose a continuous series: thin fusiform, swollen fusiform, pyriform, globose, with all intermediate stages.

When two diameters are given, the first is that of the sagittal plane determined by the obliquity of the base. Whenever a difference can be detected, the sagittal diameter is greater than the transversal; in this respect the species differs from most, if not all, others discussed in this memoir. Usually the sagittal plane is also the dorso-ventral plane, but we cannot prove that it is so in this species.

The numbers of ribs and pustules are estimated at the level of the greatest diameter. When variation occurs on different faces, the finer ribs contain the smaller pustules. The ribs of E 9514 are smooth, perhaps worn, so that the pustules, if they existed before petrifaction, can not be counted (compare LAUBE, 1865, f. 13 *a*, *g*). The pustules are normally rounded, borne on the ribs, and subequal on each rib. In E 9517 the ribs are thin, equally spaced all round, and the pustules are spinelets with a rake distalwards; this specimen approaches most nearly LAUBE's figures 13 *b*, *f*, and KLIPSTEIN's figure 14 *g*. There does not appear to be any definite correlation between the size or spacing of ribs and pustules and the axes indicated by the oblique base: no finer ornament on a possible adoral face, no intensification of lateral ribs. Owing to the approximate equality of ribs and pustules, the ornament has at first sight a regular appearance; but closer examination shows that a rib rarely passes from end to end of the shaft, and that when it does so, its course is usually curved. Often the ribs that are strongest at the distal end die out proximally (E 9517), often other smaller ribs appear in the middle of the shaft, especially in the more swollen forms, and often the ribs as they pass distalwards coalesce by twos or threes, bending to the right or the left. Thus the ornament is far from having the essential regularity of such a form as *C. similis* or even *C. Waechteri*, and this no doubt throws some light on the peculiarities of the microstructure.

The base in all these specimens is oblique, but its most characteristic feature is the collerette: this is very short, and widens rapidly to a well-marked distal rim, which at first sight is liable to be mistaken for the annulus. The annulus scarcely projects beyond the collerette, but below it the base is greatly constricted, perhaps sometimes undercutting the annulus. Then the base swells out again, bead-wise, proximally, and is crowned by a small swollen acetabular margin. The general appearance is as though one had taken a base, fashioned in some soft material, and telescoped it towards the shaft, thus shortening and swelling each of its members. When the small acetabular margin has been worn away, the bead-like base itself may be taken for that margin, the slope from the annulus to the collerette may be confused with the slope of the base, and the collerette, as already said, may be mistaken for the annulus.

The acetabulum shelves gradually to a central pit. Its margin, though oblique to the main radiole axis, is not so oblique as the collerette; therefore the telescoping, if one may so express it, has been more on one side.

There is no crenelation on any structure of the base. A very fine longitudinal striation can just be made out on the collerette in the best preserved specimens.

The micro-structure has been briefly described by HESSE (1900, p. 228) who gives a diagram of it. From the almost imperceptible axial complex he shows a septum radiating to each of the outer ribs; and from each side of these main septa he sees short, more delicate septa, given off at regular intervals, at an angle of about 45°, passing towards the periphery, and abutting on the corresponding septa from the adjacent radiate septum. These side septa are drawn as regularly spaced, slightly curved, and united by regular straight trabeculae.

The beautiful drawing by Mr. G. T. GWILLIAM (Pl. XVI, fig. 448) is an accurate representation of part of an excellent cross-section (E 9518). While it recalls Dr. HESSE's diagram, its details are very different. There are no main radiating septa, but a number of irregular, more or less equivalent septa, having a general tendency to radiate from the centre; this regularity and centrifugal arrangement increases towards the periphery, where also the septa become markedly closer and finer, about 75 to the millimetre, with the meshes between them smaller and more regular. Thus far the description might apply to such a form as *Cidaris dorsata*, or to *C Waechteri* were it not for the axial complex of that species; but the obvious difference lies in the grouping of these septa into a number of fan-systems. The starting-points of these are marked in the section by darker patches, which are not easily explained. Some of these dark patches are seen near the centre, but in that region the fan-systems are developed very slightly or not at all. In the peripheral region also no fresh fan-systems seem to originate, but the septa arising from those in the deeper layer continue and dichotomise, and fan out in the ridges in a manner that is quite usual. In this peripheral region, at a little distance from the exterior, is a dark band, which seems to coincide with a region of dichotomy and consequently of closer septa. It may be that, with the further growth of the radiole, this band would break up into nuclei of fan-systems, each system marking the former position of a ridge. Now, if the ridges were regular and always stayed in the same relative position, the fan-systems would form a continuous series along a radial line. Possibly in a young radiole, or in a section near the base, this would be the case, and the general appearance would no doubt then approach that indicated in Dr. Hesse's diagram. But, as we have seen, the ridges in the adult shaft are not regular: they wave and are separated by newly-formed ones and again coalesce. Probably, then, they shift their relative positions during growth, and so successive fan-systems cease to lie in a straight radial line. Resorption and redeposition of stereom, in the manner well known among Echinoderms, probably take place in the deeper layers and further obscure the supposed original symmetry. Thus it may be possible to harmonise Dr. Hesse's diagram with my more elaborate drawing.

An accurate study of a single well-marked fan-system (fig. 449), on a scale of magnification three times as great, shows that it starts from a complex of irregular meshes, for the most part larger than those of the ensuing radiate portion. This initial complex changes rather suddenly into a radiating mesh-work with elongate meshes; as the septa spread out they fork, and the meshes also widen. Each system, then, repeats in little the system of an ordinary type such *C. Waechteri*, and the initial complex is as it were a repetition of the axial complex. In these Echinoderm tissues, where stereom is less stroma is more; and the function of the ordinary axial complex is to convey nutrient fluid through lacunae in the stroma, and to facilitate the passage of nerves. In cases of fairly rapid fossilisation, whether of Echinoderms or of other invertebrate skeletons, the stroma does not all decompose but becomes carbonised, and those tissues or tracts of the stereom in which it was most abundant are therefore marked in such fossils by a darker colour.[1] This may explain the darker patches that mark the initial complexes, even though the darkening substance can not be resolved into grains of carbon, as it can in the radioles of *C. trigona*.

[1] For proof and examples of these statements. see «Note on the colour of certain Cyathocrini» in Bather, 1893, «Crin. Gotland, I.», Svensk. Vet.-Akad. Handl. XXV, No. 2, p. 151. Compare the interesting paper by R. Bullen Newton, 1907, «Relics of coloration in Fossil Shells», Proc. Malac. Soc. London, VII, pp. 280—292, pl. xxiv.

Material from Bakony. — A single radiole from the Cassian beds of Cserhát (Leitnerhof). (Pl XII, figs. 368, 369.)

Shape between pyriform and fusiform.

Length, 4·8 mm. Greatest diameter, 1·7 mm. Diameter at annulus 0·8 mm. 3 ribs, and 3—3·5 pustules, in a width of 1 mm. The characteristic basal structures, though somewhat worn, can be distinguished (fig. 369).

«*Cidaris*» *Hausmanni* mut. nov. *tofacea*.[1]

(Plate XII, figs. 370, 371.)

1904. *Cidaris Hausmanni* Wissm., Broili: Palaeontographica L, p. 154, pl. xvii, ff. 25, 26.

Diagnosis. — *C. Hausmanni* of smaller size, the average length being 3·5 mm.; ridges obscure and changing into obscure, irregular pustules at the distal end of the shaft, with intervening grooves relatively narrow, pustules of ridges obsolete or nearly so; base less oblique than in the typical form.

Holotype. — The specimen figured Pl. XII, figs. 370, 371. (Brit. Mus. E 4697 *a*), from the Pachycardientuffe of the Seiser Alp.

Broili states that the radioles are common on the Seiser Alp; he describes them as small and as easily recognised by the regular rows of pustules. I have examined his numerous specimens at Munich, and have more closely studied three taken therefrom at random and now in the British Museum (E 4697 *a*, *b*, *c*.)

	Broili f. 25	Broili f. 26	B. M. *a*	B. M. *b*	B. M. *c*
Shape	Pyriform	Swollen fusiform	Irregular swollen	Oblique thyrsiform	Swollen fusiform
Length .	3·4	3·7	3·2	3·2	3·4
Greatest diameter. . . .	1·8	1·8	2·15 2·0	2·2 2·4	2·0
Diameter at annulus	0·5	0·7	0·9	1·0	ca. 0·8
Number of ribs in a width of 1 mm.	4	3	2·5—3·5	3·4	ca. 3
Number of pustules in a length of 1 mm.	—	—	? 3·5	—	—

As regards size, the preceding table, based on Broili's figures and on the three British Museum specimens, shows that these radioles are considerably shorter than the Cassian forms, the respective averages being about 3·5 and 6 mm. Their diameter is also less, but not so much less, for their shafts are relatively stouter, rarely thin fusiform, but swollen and rather irregular.

An extreme regularity in the ridges is indeed depicted in Broili's figures; but in the first place this, as already shown, is not characteristic of *C. Hausmanni typica*, and in the second place, it is not constant or even common in the radioles from the Pachycardientuffe. Here the ridges are quite as wavy and anastomosing as in the Cassian radioles, and have the further irregularity that none passes clearly to the distal end, which is covered with confused pustules.

As for the pustules, «Körner», said to compose the ridges, they are conspicuous by their absence in Broili's own figure 26, and scarcely to be detected in a fused

[1] *Tofaceus* or *tophaceus*, because found in *tophus*, tuff.

or obsolescent state in his figure 25. The latter appearance is, in fact, that presented by all specimens in which the faint traces of pustulation have not been worn away.

The average number of ridges to a millimetre appears to be 3·4, whereas in the Cassian radioles examined it was 2·7. The ribs do not, however, appear so much thinner as this might imply, partly because the absolute diameter of the radioles is less, partly because the absence of sharp pustules and the reduction in width of the grooves between the ridges increase the apparent and the relative width of the ridges.

The base has the same general structure and about the same proportions as in the Cassian radioles, but the obliquity is not so marked; oddly enough, it is not shown at all in BROILI's figures.

The numerous differences here pointed out are so clear and so constant in the material available, that it does not seem right to record *Cidaris Hausmanni* from the Pachycardientuffe without some qualification. These radioles seem to indicate a permanent mutation from the Cassian species.

No examples of this mutation are yet known from Bakony, but they may easily have been overlooked owing to their small size.

Relations of the Species. — With our present knowledge, *Cidaris Hausmanni* appears one of the most distinct of all Triassic Echinoid radioles, and yet the small size, the entire absence of dorsoventral compression, and the peculiar features of the base render it doubtful whether it is a normal peripheral radiole. From whatever region of the test these radioles may have come, we are unable to associate with them any known forms that may have come from the other regions. In some respects they remind one of the smaller examples of *C. dorsata*, with which indeed QUENSTEDT confused them. They are also liable to confusion with small radioles of *C. alata*.. These resemblances may depend on some actual relationship.

Cidaris cf. *dorsata* et *Hausmanni*.

(Plate XII, figs. 372—374.)

Material from Bakony. — The Cassian beds of Cserhát have yielded 6 very small radioles (*a*—*f*), which, though generally resembling *C. dorsata*, differ so greatly in size from the normal forms that they demand separate treatment. A similar radiole (*g*) comes from the Lower stratified Limestone of Giricses-domb, Veszprém.

Description of the Specimens. — The following table gives the chief measurements in millimetres.

	a	*b*	*c*	*d*	*e*	*f*	*g*
Length	3·8	3·8	4·5	4·6	4·6	3·6	4·0
Greatest diameter . . .	1·7 1·6	ca. 1·7	1·3 2·3	1·7 1·8	2·0	1·8	2·1 1·9
Diameter at annulus . .	0·7	0·9	1·1	1·0	1·0	—	—

In *c* the shaft is crushed, so that the difference between the diameters is exaggerated. In *f* the base is broken off. In *g* most of the base is broken off, so that the length probably did not exceed 4·6 mm.

When two diameters are given, the former is that in the sagittal plane indicated by the obliquity of the base. This is not always very clear, but on the whole it appears that the difference between the sagittal and transversal diameters is slight, and not markedly in favour of either.

The shaft is slightly pyriform or swollen baculiform. It is ornamented with small obscurely marked pustules, closely set, either irregularly scattered or in longitudinal series. The pustules run from 3 to 4·5 to the millimetre in each direction. There are no distinct grooves between the longitudinal series, and their pustules are not borne on ridges.

The base is always oblique; but the obliquity varies and is never strongly marked, nor does its direction seem correlated with the shape of the shaft.

There is no distinct collerette; the annulus is rounded and smooth; the acetabular margin is a smooth prominent ring.

Relations of the Form. – These resemble the radioles that QUENSTEDT (1875, p. 194, pl. lxviii, ff. 69 71) took to represent *C. Hausmanni*, and referred to *C. dorsata*. They resemble *C. Hausmanni* in size and to some extent in the seriation of the pustules, and they approach it in the obliquity of the base. They differ from the typical *C. Hausmanni*, however, in the absence of a marked collerette-rim and of ridges on the shaft. The ornament is more reminiscent of *C. Hausmanni tofacea*, but from this too the specimens differ in the other characters. Consequently I donot think that they have any more to do with the true *C. Hausmanni* than QUENSTEDT's specimens had, although they may indicate a variation towards that species.

Whether these small radioles should be referred to *C. dorsata* is another matter. Their characters are fairly well defined, so that they do not seem to be merely young forms They may possibly be secondary radioles of that species; but if secondary, then they might well belong to some other species of very different character.

*Cidaris parastadifera.**

(Plate XIII, figs. 375—392 & Plate XVI, fig. 447.)

1865. *Cidaris parastadifera* K. E. SCHAFHÄUTL: N. Jahrb. f. Mineral., 1865, p. 796, pl. v, f. 8 *a—d*.
1865. *Cidaris* cf. *marginata* lit. GOLDFUSS, K. E. SCHAFHÄUTL: op. cit. p. 791. pl. v, f. 2, 2 *a*.
1889. *Cidaris parastadifera* SCHAFH., S. v. WÖHRMANN: Jahrb. geol. Reichsanst Wien, p. 195, pl. v. f. 19.

Diagnosis. — A Cidaroid in which the primary radioles have a microstructure of fine, close-set septa crossing in curves at oblique angles and disposed fan-wise near the periphery, with a small axial complex; in which normal (peripheral) radioles are baculiform, with shaft dorso-ventrally compressed, and ornamented with regular longitudinal ridges bearing strong, discrete, subequal pustules, thorn-like or swollen, more pronounced on one [? adapical] side; adoral radioles more lanceolate; adapical radioles more subclaviform; collerette low but distinct, smooth; annulus rounded, smooth; acetabular margin prominent, smooth.

Holotype, the oral surface of an Echinoid, in which the structure of the test is indistinguishable, surrounded by 11 radioles: original of SCHAFHÄUTL's figure 8.

Type-locality, Wettersteingebirge.

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* This mongrel word (melius *parastadophora*) means *pilaster-bearing*.

Horizon, «in einem gleichfalls schwarzgrauen, etwas verwitternden und dann schmutzig gelblichbraun erscheinenden Kalksteine», now recognised as Raiblian.

Remarks on previously described Specimens. — The radioles of the holotype are peripheral and infra-ambital. Those referred by SCHAFHÄUTL to *C. marginata,* and transferred by WÖHRMANN (1889, p. 195) to *C. parastadifera,* are probably circumapical or possibly secondary radioles.

The localities given by WÖHRMANN are Ostreenkalk of Haller Anger, Bärenalpe, etc. The original of his fig. 19 is from Ueberschall, Haller Anger, and is preserved in the Palaeontological Museum, Munich, the authorities of which have kindly permitted me to study it (Pl. XIII, fig. 375). The holotype I have not seen, but SCHAFHÄUTL's account and figures are so clear, and have been so thoroughly checked by WÖHRMANN, that this is no serious omission.

Material from Bakony. — Fragments from beds *a* and *b* of Cutting IV on the Veszprém-Jutas Railroad number 648, a few being on matrix; from Cutting I are 12, without bed designated, and 6, of which some are doubtful, labelled bed *e*; from the quarry near Cutting I are 129, four being on matrix; from Jeruzsálemhegy, 43: — Total = 837. Although the species is abundant at Cutting IV, most of the specimens are very fragmentary, and a large number are obscured by an oolitic growth; those not thus broken or obscured are chiefly the smaller forms. The specimens from the other localities are as a rule better preserved, and since the largest selection is afforded by the Quarry near Cutting I, the following account will be based on those except when other localities are definitely mentioned.

In length complete radioles range from 4·5 mm. to 11·6 mm.; but some fragments indicate radioles of slightly greater length. The longest complete radiole is one on matrix from Cutting IV, 12·7 mm. long, and there is no evidence that this length was ever exceeded. The mean between these two extremes agrees almost exactly with the 8·5 mm. given by SCHAFHÄUTL as the average length.

In shape the radioles, whatever their length, vary much, being either baculiform, or sub-clavate, or bilaterally compressed and lanceolate, with all intervening variations, and even triangular in section. The major axis is generally straight, but may be curved, even markedly so. *Pari passu* with the variation in shape, the greatest thickness varies much, both absolutely and in relation to the length. This will be clear from the following measurements.

	Length	Dorsoventral diameter	Transverse diameter	Ratios of diameters to length
Baculiform	10·2 mm.	0·7 mm.	0·85 mm.	0·068 and 0·083
Subclaviform	8·6	2·2	2·4	0·25 and 0·27
Lanceolate	10·8	2·0	2·9	0·18 and 0·26
Lanceolate	8·8	1·5	2·3	0·17 and 0·26
Subclaviform fragment. .		3·2		
Flattened fragment . .		2·7	4·0	
Baculiform, Cutting IV.	12·7	ca. 1·6	2·1	0·12 and 0·16
Subclaviform, Jeruzsálemhegy	9·4	3·2	3·4	0·34 and 0·35
Flattened subclaviform, Jeruzsálemhegy . . .		3·3	3·7	

The average diameter given by SCHAFHÄUTL is 2 mm. (i. e. 0·23 of length). The mean of the extremes presented by the Bakony radioles is 0·21; but this is certainly below the average, for the very thin shafts are rare in comparison with the very thick ones.

The ornament varies no less than the shape, so that, were it not for the complete series of gradations, many of these specimens would scarcely have been referred to the same species as the two varieties of form hitherto described. Those two varieties are also found in the Bakony material. The longer form of the holotype is said by SCHAFHÄUTL to have at most 9 longitudinal ridges, of which 4 are visible from any one side; these ridges meet distally in a very low, somewhat conical point; each ridge is beset with a row of usually 9 pustules one above the other, with a distal rake, elliptical, swelling towards their ends, usually in horizontal rows, but also often alternating; between each ridge is a narrow linear space. This description implies a subcylindrical shaft with ridges evenly distributed, and such do actually occur. It is, however, doubtful whether the radioles in the holotype are of this nature; they lie on the matrix, so that only one face — the adapical — is seen, and the wording of the description is quite consistent with the more probable view that the shafts are compressed and the ornament not evenly distributed.

By far the greater number of the shafts from Bakony show some sign of dorso-ventral compression. When this is well marked the pustules on the lateral ridges are the most prominent and produce a serrate edge (figs. 381, 385)); the supposed adapical face is the more rounded (fig. 383), and bears more prominent ridges and pustules than does the adoral face; this latter is relatively flattened and usually bears finer and more closely set ridges with less pronounced pustules. In thin, elongate radioles, the adoral face is often quite smooth (fig. 388); in more lanceolate radioles, that face may be smooth in its proximal half, becoming ridged distally; in the more swollen, subclaviform radioles, its ornament is better developed and differs but little from that of the adapical face (figs. 376, 377).

The smallest number of ridges observed is 3, namely two lateral and one in the middle of the adapical face, the adoral face being quite smooth. The long radiole from Cutting IV has 4 ridges on the adapical face. Compressed lanceolate forms may have as many as 6 ridges on the adapical face, accompanied by 3 to 5 on the adoral face. A rather more claviform shaft from Jeruzsálemhegy has 7 or perhaps 8 adapical ridges, and 5 adoral with a trace of a sixth. The regular subclaviform shafts have about 12 ridges as a rule, but two of this shape from Jeruzsálemhegy have as many as 16.

The short swollen radioles, referred by SCHAFHÄUTL to *C. marginata* are no doubt short examples of the subclaviform type, and it is consistent with this that they were said to have 10—12 ribs. SCHAFHÄUTL's figures, however, cannot be said to indicate more than 6—8 ribs in all. The smallest complete subclaviform radiole in the Bakony material is from Jeruzsálemhegy: 5·3 mm long, greatest diameter 1·6 mm., number of ribs 10. This specimen does not agree with SCHAFHÄUTL's statement that the handle is one-third the length of the radiole, since it is only 0·8 mm. long; but then the statement is equally inapplicable to the specimen shown in SCHAFHÄUTL's figure 2*a*. Although then the Bakony material yields no specimen precisely agreeing with SCHAFHÄUTL's description of this form, still it contains several radioles near enough to show that WÖHRMANN was probably correct in referring the form to *C. parastadifera*. (Figs. 376, 377).

The pustules have in general the shape described by SCHAFHÄUTL; in many specimens they closely resemble his figure 8 *d*. The lateral series in compressed radioles and the distal-most pustules of subclavate radioles are more thorn-like, and in some specimens the pustules have longer stems with cylindrically rounded backs. In nearly all specimens the pustules are mounted on ridges; but occasionally, on the adoral face or near the distal end of a subclaviform radiole, the pustules seem to rise directly from the body of the shaft. Sometimes on the adoral face the pustules can scarcely be detected, while the ridges, especially in the distal region, are quite well marked. These ridges generally pass almost straight from their commencement at the proximal end of the shaft to the distal end, where they may die out or merge. Occasionally they curve, sometimes without apparent reason, sometimes to admit the intercalation of fresh ridges in a rapidly swelling shaft, or to take the place of ridges that die out in a tapering shaft.

SCHAFHÄUTL gives the number of pustules to a ridge as 9 in a radiole of 8·5 mm. In the Bakony material this number is found in the lateral series of some specimens of the same length, but the number in the other rows is greater, namely, 10 or 11 on the adapical face and about 14 on the adoral face. In the long radiole from Cutting IV, one of the ridges on the adapical face is 11·5 mm. long and bears 18 pustules; these are small and close together in the proximal region, but half-way down the shaft 3 go to every 2 mm. A stouter radiole from Jeruzsálemhegy has 20 pustules in a ridge 11 mm. long on the adapical face, the increased number being due not to greater closeness but to the curvature of the ridge.

The pustules are occasionally in transverse rows on one face of the radiole, if not all round it; but it follows from the different sizes of the pustules in the different ridges that this arrangement can not be «usual», as SCHAFHÄUTL calls it. Frequently the difference between the ridges is such that the pustules of adjacent ridges are in no obvious relation. In the subclaviform radioles, where the pustules are of more equal size, they are often so disposed as to form oblique series crossing one another.

The base is small in proportion to the size of the radiole; the acetabular cavity deep; the acetabular margin a raised rim, not crenelate, though occasionally irregular in consequence of weathering (fig. 379); the base then swells slightly, again is slightly contracted and then passes into the smooth, prominent, rounded annulus the collerette is a smooth low depression between the annulus and a step where the shaft begins (figs. 382, 389). The rapid succession of these smooth, low rings and depressions explains WÖHRMANN's curious description of the base as «mit concentrischen Rinnen bedeckt» All the structures of the base, but especially the annulus, usually slope from the adoral face towards the adapical in a proximal direction. This indicates a normal downward slope of the radiole, with exposure of its adapical face.

The following are measurements of the base in millimetres:

Greatest diameter of shaft	1·5	2·0	3·1
Total height of base	0.7	0·6	1·0
Height to top of annulus	0.55	0·5	0·85
Diameter of annulus	1·2	1·1	1·4
Outer diameter of acetabular margin	0·8	0·6	0·85

As the preceding description of outer form will have shown, the normal limits of variation are considerable. There are, however, yet other specimens most probably belonging to this species, but departing still further from the norm.

A radiole from Quarry near Cutting I, 4·7 mm. long, subclaviform, with greatest diameters 1·7 and 1·8 mm, diameter at annulus 0·8 mm., has a smooth handle, distal pustules well developed, few, and rounded, beginning lower down on the adapical face. This probably comes from the circumapical region.

From Cutting IV is a fragment of triangular section; the adoral face, which is rounded proximally, becomes almost flat distally and slightly ridged, while the adoral face rises by flat sides into a median angle, the pustules being stronger on the angles; the main axis is slightly curved to one side, as well as being concave on its adapical face; greatest diameters 2·1 and 2·9 mm.

From the Quarry near Cutting I is a radiole lying on matrix, with the adoral face exposed (Pl. XIII, fig. 392); this is slightly lanceolate in outline, and is quite smooth except for a faint ridge near the distal end; as first seen, it was peculiar in having two prominent thorn-like pustules projecting distalwards about two-thirds of the way down the right side, and a single similar pustule on the left; further removal of the matrix showed that these apparently isolated thorns were merely members of the lateral series, and that pustulate ridges were well-developed on the adoral face. Length, 10·7 mm.; greatest transverse diameter 2·9 mm.; diameter at annulus 1·1 mm.

The micro-structure has been studied in three sections of radioles from beds *a*, *b* of Cutting IV, but only one of these could be deciphered This was a task of much difficulty, owing in part to the poor preservation of the section, but still more to its very unusual structure. The appearances that can be detected have been most carefully drawn by Mr. G. T. Gwilliam (Pl. XVI, fig. 447.), who has adequately grasped the essential facts of this most obscure structure. There seems to be a central complex, possibly breaking down into a lumen. A darker patch indicating the presence of this structure can often be detected in broken ends. Towards the periphery septa are fairly distinct in places, and seem to fan out where the ridges occur; this is often the case with the ordinary radiating septa in pustulate radioles of other Triassic species. In the region between the outer layer and the axial complex, the meshes of the stereom are much finer, and are not composed of radiating septa and trabeculae. The appearance is as though the outer septa of the several ridge-systems continued inwards, curving in the same direction, that is to say, continuing the ribs of the fan, and therefore crossing one another at an acute angle. It further appears that under the grooves between the ridges the septa fan centripetally, and these also cross the septa previously mentioned. No guiding lines of any kind can be distinguished, and the stereom in the intermediate region is extraordinarily dense. On the periphery the septa are about 80 to the millimetre.

Relations of the Species. — There are several Cassian species to which, in one or other of its many forms, *Cidaris parastadifera* presents a resemblance.

As already mentioned under *Cidaris similis,* it is often hard to distinguish between that species and the normal baculiform radioles of *C. parastadifera*, so far as outer form is concerned. The chief difference appears to lie in the absence of longitudinal striation from the annulus, collerette, and shaft of *C. parastadifera*. This difference doubtless depends on the greater fineness of the micro-structure, in which still further dissimilarity may be observed. The peripheral septa on the ridges and pustules have here only half the width of those in *C. similis,* and therefore produce no surface-ornament visible under a hand-lens. Further, the septa are soon lost in the general confusion of the inner layers, whereas in *C. similis,* however wavy their course may be, they can always be distinguished.

Many of the compressed lanceolate radioles are not unlike small examples of *C. Waechteri,* while others less compressed might possibly be compared with *C. Wissmanni.* From these species, however, *C. parastadifera* is adequately distinguished by the ridges on which the pustules are mounted, not to mention the very distinct micro-structure.

Some of the smaller compressed specimens also remind one strongly of *Cidaris spinulosa* KLIPST. (= *C. perplexa* DESOR). This form has been fully discussed under the heading *Cidaris Waechteri* (p. 191).

The subclaviform radioles are often suggestive of the little-known species *Cidaris austriaca* DESOR (1855, p. 20, pl. ii. f. 14) based on *C. ovifera* KLIPSTEIN (1843, p. 271, pl xviii, f. 8 *a, b*) non AGASSIZ. The differences noticeable are the striation of the collerette and the absence of pronounced pustules in *C. austriaca,* although it is obvious that the ridges are formed of fused pustules. I cannot stay here to describe the original specimens of this species (Brit. Mus 36499), but I may say that the figured one, which I take as lectotype, is probably related rather to *C. Hausmanni* than to any other Cassian species.

In the collection of the Geological Survey at Budapest, are some small radioles like elongate *C. Hausmanni,* with thorn-like pustules in longitudinal rows. They are said to come from St. Cassian, but, so far as I remember, they are more like *C. parastadifera* than any other Cassian form. They were obtained from KLIPSTEIN, and bear a printed label issued by him with the name «*Cidaris Klipsteini* GÜMBEL». GÜMBEL (1861, p. 274) seems to have intended this name for radioles of Raiblian age from the Lödensee at the foot of the Kienberg. He did not, however, figure or describe these, except by saying that they agreed very well with KLIPSTEIN's pl. xviii, f. 16. But that figure represents a fragment of test, which, oddly enough, was already the holotype of *C. Klipsteini* DESOR (1855, p. 4), a species for which I have on page 84 used the name *Miocidaris Cassiani* BATHER (1909, p. 61). It seems impossible that GÜMBEL can have intended to refer to this figure, and his *C. Klipsteini* is therefore a n o m e n n u d u m, as well as a doubly preoccupied homonym. The original *Cidaris Klipsteini* is due to MARCOU in AGASSIZ & DESOR (1847, p. 140) and was unjustifiably called *Cidaris ampla* by DESOR (1858, p. 484). Its holotype is the fragment of radiole figured by KLIPSTEIN (1843, pl xviii, f. 5) as *Cidaris d'Orbignyiana* (non *C. Orbignyana* AG. 1840, p. 10), and is in the British Museum [E 4601]. Obviously it has nothing to do with *C. parastadifera* or any related species; but it should have been equally obvious from KLIPSTEIN's description and figures that it could have nothing to do with *C. semicostata,* to which it was referred by LAUBE (1865, p. 289) and BROILI (1904, p. 157). Without entering into a description of the interesting original, I may say it that appears intermediate between *C. Waechteri* and *C. flexuosa,* but that the evidence for referring it to either of those species is quite inadequate.

The only other species that needs mention in this connection is *Cidaris Hausmanni,* with which some of the smaller subclaviform radioles of *C. parastadifera* might be compared. The ribs of that species are finer and the pustules smaller, but it is rather the similarity of the micro-structure to which I would direct attention. There is in *C. Hausmanni* (Pl. XVI, figs. 448, 449) the same curious fanning and crossing of the septa, a structure to be seen in no other Triassic species. The oblique base of *C. parastadifera* is another point of resemblance, though it is not so marked as in *C. Hausmanni*.

It appears then that the Cassian species most nearly related to *C. parastadifera* are *C. similis* and *C. Hausmanni* This further suggests that *C. Hausmanni* may represent the circumapical radioles of *C. similis*, just as the subclaviform radioles here assigned to *C. parastadifera* probably represent the circumapical forms of the Raiblian species. Should this suggestion be confirmed, it would certainly help to elucidate the curious micro-structure.

«*Cidaris*» *decoratissima*.

(Plate XIII, figs. 393—398.)

1865. *Cidaris coronata* GOLDFUSS, K. E. SCHAFHÄUTL: N. Jahrb. f. Mineral., 1865, p. 790, pl. v, f. 1.
1889. *Cidaris decoratissima* S. v. WÖHRMANN: Jahrb. Geol. Reichsanst. Wien, XXXIX, p. 196, pl. v, f. 20

Diagnosis. — A Cidaroid in which the primary spines have a probable micro-structure of regular radiate septa and regular trabeculae in the collerette, but irregular wavy septa and curved trabeculae in the shaft, probably enclosing a lumen or loose axial complex; shape baculiform or fusiform; shaft ornamented with strong longitudinal ribs, more or less broken into pustules in the proximal region; collerette striate, long (or short); annulus rounded, striate; acetabular margin prominent coarsely crenelate.

Lectotype, the radiole figured by SCHAFHÄUTL (1865, pl. v, f. 1), from the Raiblian Ostreenkalk of the Zugspitze, Wettersteingebirge, also figured by WÖHRMANN (1889, pl. v, f. 20), and now in the Palaeontological Museum, Munich.

The localities given by WÖHRMANN (1889, p. 196) are «Ostreenkalk vom Wettersteinzug, Kienleiten und Judenbach».

Description of the Lectotype. — A complete primary radiole (Pl. XIII, fig. 398.), sub-baculiform, swollen in lower third of shaft. Length, 19·3 mm. Greatest diameter, which is about 10·5 mm. from acetabulum: dorsoventral, 3·75 mm.; transverse, 3·9 mm., i. e. 0·2 of length. Thence the shaft tapers to 1·5 mm. at distal end, finishing abruptly in an almost flat top; and to 3 mm. at proximal end, about 7·4 from acetabulum.

Shaft ornamented with longitudinal ribs, of which 10 reach its distal end, where, as seen from above, they resemble equidistant septa meeting in a granular columella. These ribs run almost straight to the proximal end of the shaft, and between them at that end are ten other ribs of equal, or even of slightly greater, size, which die out at about 1·5 mm. from the distal end. On one face of the shaft all these ribs are strongly and equally developed, with grooves of about the same width between them, and on this face, at the thickest part of the shaft, the width of a rib and a groove is almost exactly 0·5 mm. On the other face, the ribs are finer, and at about the thickest part of the shaft there are intercalated between them incipient ribs, of which one is 4·7 long, while the others are little more than scattered granules. Extreme height of ribs from bottom of grooves varies from 0·2 to 0·4 mm., the latter height being attained only at the proximal end. Ribs broken up into (or formed of coalesced) pustules; these are larger and more discrete at the proximal end of the shaft, where four occupy a length of 2·4 mm.; about the middle of the shaft five occupy the same length.

Base occupies about 0·38 length of radiole, this high proportion being due to the collerette, which measures 5·8 mm., and is bounded distally by a slight but distinct rounded rim, partly formed by the proximal pustules of the shaft. This rim, although equidistant from the annulus, is not at right angles to the main radiole-axis, but slopes distalwards to that face of the shaft on which the ribs are the more distinct. With this rim the annulus and acetabular margin are parallel. Least diameter of collerette (dorsoventral, 2·2 mm.; transverse, 2·3 mm.) at one-quarter of its length from the annulus; thence the collerette swells to 2·8 and 3 mm. at the distal end, and 2·6 mm. next the annulus. The curve produced by this swelling is more concave on that face which has the more distinct shaft-ribs; thus the main radiole axis is slightly bent towards that face. Surface of collerette marked with linear striae, 25 to the millimetre; these represent the outcropping edges of regularly radiate septa, and regularly spaced trabeculae are seen between them.

Annulus rounded, separated by a clear step from the collerette, but passing gradually into the slope of the base Diameter 3 mm., height about 0·6 mm. Longitudinal striae of the same size, but more clearly marked, pass directly from the collerette over the annulus, and die out on the slope of the base, which is straight or faintly convex.

Acetabular margin circular, prominent, slightly curved downwards dorso-ventrally, and coarsely crenelate, with an outer diameter of 2·1 mm From the margin the sides of the acetabulum gently shelve inwards, and then suddenly bend down to form a pit with vertical sides and a diameter of 0·85 mm. Total depth of acetabulum 0·7 mm.

The micro-structure may be inferred to some extent from the study of the surface. In the region of the collerette there would doubtless be an outer layer, probably extending to an axial complex or lumen, composed of regular radiate septa with regular trabeculae. In the grooves of the shaft the vertical edges of the outcropping septa are seen to wave, dichotomise, and anastomose, at irregular intervals, and about 15 occupy half a millimetre (fig. 397). The trabeculae are often arched convexly upwards. It may therefore be supposed that in this region a transverse section would show similarly irregular and waving radiate septa with an irregular meshwork.

The Characters of the Species. — The lectotype was the only specimen known to Schafhäutl, and appears to form the sole basis of Wöhrmann's description, though some other specimens or fragments must have been known to him. These facts, as well as its excellent preservation, may lead one to exaggerate the importance of this single specimen, and to regard as diagnostic of the species characters that may be merely individual. For example, the variation in length of collerette observed in some other species should make one hesitate to regard its unusual length in the lectotype as a necessary character. The number of ridges certainly must be expected to vary with the size of the radiole, and even in the lectotype it is not so precise as at first appears. The constitution of the ribs may also be expected to vary: the incipient ridges of the lectotype are formed of isolated granules; the next stage is a ridge broken up into pustules, which, as the ridge is followed distalwards, seem to fuse, until the distal portion of the ridge is a bare unornamented keel: any of these stages might be more dominant in an older or younger radiole, or in one from a different part of the test. The obliquity of the basal structures is almost certainly a feature correlated with position on the test, and a constant character of no species.[1] The crenelation of the acetabulum, when so irregular as in this specimen, has rarely great importance.

Material from Bakony. — The preceding remarks may explain why it is that the following specimens are dealt with here, although they do not closely resemble the lectotype. They are 4 complete radioles and 3 fragments from the Raiblian of Jeruzsálemhegy, and one fragment from a limestone at Veszprém, Alsó Erdő (lower wood) assigned to the horizon of the Reingrabner Schichten, presumably Lower Raiblian.

The last mentioned fragment is exceedingly imperfect, but shows on one side six ridges, apparently composed of fused pustules and like those of *C. decoratissima.*

Of the specimens from Jeruzsálemhegy, the one superficially most like the lectotype is the proximal half of a radiole (Pl. XIII, fig. 393.), with a similarly oblique base and curved handle. The collerette, however, is much shorter, so that the curvature affects the proximal region of the shaft. The ribs of the shaft number 11, and are broken up into pustules proximally, while distally they form plainer ridges. It is in this last respect that the specimen seems to approach *C. decoratissima* rather than *C. parastadifera.*

Another proximal portion from Jeruzsálemhegy has about 20 pustulate ribs; some of them, which are finer and more broken up than the rest, are grouped in two longitudinal depressions, asymmetrically placed one on each side. The broken distal end shows a central marking suggestive of a large axial complex or lumen filled with secondary calcite. The looseness of the interior may have led to some crushing during life, and thus given rise to the depressions with their finer ribs. For the rest, the ornament resembles that of *C. decoratissima,* and the measurements are greater than in *C. parastadifera.* The collerette, however, is quite short. Diameter at annulus, 3·4 and 3·8 mm.; at distal end, 3·6 and 4·5 mm.

The four fairly complete radioles from Jeruzsálemhegy are ill-preserved and weathered, and at least one of them was rolled before fossilisation. Therefore, though the ribs are clearly shown, the pustulation is but obscurely indicated. In one of the specimens (fig. 396), which is short, and rather swollen, the ribs are strongly marked, and probably were but slightly pustulate. Between some of them are indications of lines of granules. Two of these radioles have a deep hollow at the distal end, indicating an axial lumen.

The remaining specimen from Jeruzsálemhegy is marked IX 57 by the collector, Professor Laczkó, and was sent to me as «*Cidaris Braunii*» (figs. 394, 395). Though only a distal half, it is well preserved and shows clearly the characters that were probably possessed by the four complete radioles. Length 13·3 mm.; diameters at proximal end, 3·8 and 3·9 mm.; thence the shaft tapers in fusiform wise distalwards. Though the dorsoventral compression is almost nil, there is a difference

[1] It is considered to be a diagnostic character of *C. Hausmanni;* but see the discussion of that species (p. 206 & p. 213).

of ornament, that on one face being four smooth ribs, tending to break into pustules at their proximal ends, while that on the other face consists of five (one incomplete) coarsely pustulate ribs, becoming smoother distally; on each side is a rib of intermediate character, completing the total of 11 ribs. But between the smooth ribs are also incipient ribs of fine pustules, five in all.

The reference of all these specimens to *C. decoratissima* may be open to question, but on the one hand I see no serious objection to this course, and on the other I can find no undoubted Raiblian species in which they would be more fittingly placed. To place them here is, at any rate, better than making a new species.

Relations of the Species. — The name is doubtless due to «eine gewisse Ähnlichkeit mit *Cidaris decorata*» (Wöhrmann, loc. cit), but if the micro-structure is such as it has here been inferred to be, then it suggests that *C decoratissima* cannot be a Raiblian mutation or direct descendant of *C. decorata*. The micro-structure of the shaft is more like that of such an irregular form as *C. Waechteri*, but scarcely so irregular as *C. dorsata*. Some of the specimens from the Cassian of Bakony herein assigned to *C. Waechteri* have an ornament closely resembling that of *C. decoratissima*, and I am therefore inclined to place the Raiblian species with that group. The coarser ornament is also not unlike that of *C. similis*, but the micro-structure is obviously different.

Radiolus raiblianus n. sp.

(Plate XIII, figs. 399—403, and Plate XVI, figs. 450, 451.)

Diagnosis. — A Cidaroid in which the primary radioles have a micro-structure of fine, slightly wavy, dichotomising septa, joined by distinct trabeculae, in the outer layer; forming larger meshes of irregular arrangement in the middle layer; and passing through a still more irregular layer into an axial lumen. In which normal peripheral radioles are baculiform, not striate, ornamented with small pustules, set as a rule in longitudinal rows, but also assuming an oblique or transverse arrangement, especially on one face of the shaft; collerette a low groove; annulus, prominent, rounded, smooth; acetabular margin prominent, smooth

Material. — Three complete radioles and 22 fragments of radioles from the Raiblian of Jeruzsálemhegy, including two from which microsections have been prepared. The more important of these are lettered *a*–*q*.

Holotype. — The radiole shown in Plate XIII, figs. 399, 400, and lettered *e*.

Description of Specimens. — Though differing among themselves in shape and ornament, these specimens have the general characters of the *Cidaris Wissmanni-Waechteri* group. The shape varies from sublanceolate, chiefly in smaller specimens, to baculiform and slightly tapering; the dorso-ventral compression is very slight, being at most 0·15 of the greatest diameter (specimen *h*). From the accompanying table of measurements it will be seen that the species attains twice the size of any specimens of *C. Wissmanni* or *C. Waechteri* from Bakony, and is still larger than any *C. parastadifera*. In the three complete specimens, *a*, *b*, *e*, the average ratio of greatest diameter to length is 0·22. These specimens are certainly among the shorter and more swollen forms of the species, and the ratio must have been less in the more baculiform radioles such as *h* and *j* (figs. 401, 403). If the ratio in *j* were no less than in *e*, the length of *j* would be 36·5 mm. But since the fragments *h* and *j* come from the distal half of the shaft, and since their rate of tapering is very slow, it is clear that such an estimate of length is far too small; *h* might well have attained a length of 60 mm.

The ornament consists almost entirely of pustules, which are rounded, tending to thorn-like, with a slight distal rake, and are, even when most prominent, quite low in relation to the thickness of the shaft; e. g. in *e* they project 0·3 mm., in *h*, at most 0·4 mm., and this last is the largest to be found. According to the distribution of the pustules, the specimens may be divided into two sets, which I do not venture to call varieties. In specimens *a*, *b*, *c*, *f*, *g*, *h*, *j*, *m*, *n*, *o*, *p*, the distribution is either quite irregular or in somewhat ill-defined longitudinal rows. The latter condition is best seen in *b*, *c*, and *f*. In these rows the pustules are far apart, from 1·7 to 2·8 mm., according to the size of the radiole, while the rows themselves are much closer, say one to a millimetre. Since the pustules alternate in position in adjacent rows, they also become arranged in oblique series, sometimes crossing as in *b*, sometimes only noticeable in one direction. In *g* and *p* this oblique seriation is clear, while the longitudinal series cannot be made out. This then forms a transition to the mode of distribution seen in specimens *d*, *e*, *k*, and *q*, where, at least on one of the faces, the pustules are in distinct transverse rows. In specimen *e* there are on one face seven such rows, those near the middle of the shaft being 3 mm apart. The pustules forming these transverse rows are also arranged in longitudinal rows, of which 6 can be traced from end to end, while in the proximal region there are two others.

Besides pustules, other features are occasionally present in the ornament, and may be studied in specimen *e*. Although the pustules are not raised on ridges, as in *C. parastadifera* for instance, still traces of ridges, formed apparently of coalesced pustules, are visible at the proximal end of the shaft on both faces, but continuing rather further on the face that does not bear the transverse rows. That face also shows fine pustules or coarse granules between the larger pustules. Other specimens show the proximal ridges, but none the granules.

The base, as may be gathered from the table of measurements, has, at the annulus, a diameter about half the greatest diameter of the shaft. The average ratio of all the specimens is 0·55.

The acetabulum is deep, usually circular; its margin prominent, rounded, smooth. From it the base slopes equably to the annulus, which is broad, rounded, smooth The collerette appears to be little more than a well-marked groove, rarely attaining a height of 0·6 mm., as in *g*, and occasionally with its distal border very slightly raised. It may be followed by a short, smooth handle to the shaft, a feature most pronounced in *e*, where it has a height of 1·1 mm., the collerette here being a mere line. The ridges and grooves of the base are usually at right angles to the main axis of the radiole, and show scarcely any trace of dorso-ventral compression.

Measurements in millimetres:

	a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*j*
Length	15·7	16·7	14·+	17·+	23·7	14·1+	23·5+	23·6+	25·7+
Greatest diam. dorso-ventral	3·4	3·4	3·5	4·1	4·4	4·6	5·2	4·5	6·6
Greatest diameter transverse	3·7	3·6	3·9	4·5	5·0	5·2	5·4	5·3	7·3
Ratio of latter to length .	0·23	0·21			0·21				
Diameter at annulus . .	1·7	2·0	2·6	2·5	2·7	3·0	3·0		

The micro-structure is well shown in two sections, and differs slightly in each. In both there appears to be an axial lumen, occupying about 0·13 of the total diameter. This lumen is ill-defined, and is doubtless produced by the breaking down or resorption of an axial complex. It is immediately surrounded by a layer of very irregular meshes, which soon merge into a broad layer of more regular structure. In one section (Pl. XVI, fig. 450.) this layer consists of meshes arranged along lines radiating from the centre, but the meshes are not so regular that their walls can be said to constitute radiating septa. Gradually, however, they become more regular, and, at about three-quarters of the distance from the centre to the circumference, merge into the outer layer of regular radiate septa. In the other section (Pl. XVI, fig. 51.) the meshes rapidly assume a regular arrangement, separated by radiate septa, but, at about two-fifths of the distance from centre to circumference, they become irregular and the course of the septa can no longer be distinguished. Then at about four-fifths of the distance the septa re-appear and rapidly dichotomise, forming an outer layer of finer mesh. On the periphery the septa are about 40 to the millimetre, but seem to become rather wider apart on the pustules.

Relations of the Species. — Just as the outer form is in several respects intermediate between *Cidaris Waechteri* and *C. Wissmanni*, so the micro-structure resembles that of *C. Waechteri* in general plan, but has the greater fineness characteristic of *C. Wissmanni* Some of the specimens remind one of the much smaller *C. Wissmanni* var. *rudis*, and the ornament of others resembles that of the smoother ovoid radioles provisionally associated with that variety. The form might perhaps be regarded as a Raiblian mutation of *C. Wissmanni*, but, even so, it seems sufficiently distinct to claim specific rank. At any rate *Radiolus raiblianus* cannot be confused with any other species from Bakony.

*Radiolus penna** n. sp.

(Plate XIII, figs. 404—412.)

Diagnosis. — Peripheral radioles having a solid feather-shaped shaft, usually smooth, with stout mid-rib and vanes of equal width distinguishable only in adapical view; aeetabular border smooth; annulus crenelate. The length of radiole (circa 15 mm.) being taken as 100, length of base is circa 9, diameter of annulus 13—15, and greatest width of shaft 33.

Material. — Five fragmentary peripheral radioles from the Raiblian of Jeruzsálemhegy *a*, *b*, *c*, *d*, *e*, of which *a* is selected as holotype. Two radioles (*f* & *g*) from the Cassian bed *e* 4 at Section VI, Veszprém, may be related

Description. — Specimens *a* (figs 404—406) and *b* (figs. 407—409) retain the base and what appears to be about half the shaft. Total length of radiole estimated at about 15 mm.

Base smooth, from acetabulum to top of annulus 1·4 mm. Annulus faintly crenelate; width, sagittally 2 mm., transversely 2·3 mm. Collerette about 0·6 mm. high, separated from the shaft by a fine incised line, and slight sharp step, preserved on the supposed adoral side of *a*; diameter, sagittally 1·8 mm., transversely 1·9 mm.

From here the shaft continues at nearly the same diameter for about 1·8 mm., when it gives off on each side a sharply marked vane. On the supposed adoral

* *Penna*, a quill-feather.

side (figs. 406, 409), the handle of the shaft merges gently into the vanes, and the back forms an equable curve. On the adapical side (figs. 404, 407, 411), the handle is continued down the shaft as a mid-rib, attaining a sagittal diameter of 2·4 mm. at 8·3 mm. from the annulus, and having a transversal diameter of about one-third the total width of the shaft. This latter gradually increases to an estimated width of 5 mm The vanes join the mid-rib on this side by gentle concave curves, almost the same as the convex curve of the mid-rib itself, but their outer margins do not rise so high as the median line of the mid-rib. (See sections, figs. 405, 408, 410, 412).

In *a* there is more tendency to a median ridge along the adoral side than on *b*, *c* or *d*. There is no trace of ornament on any part of *a*, *b*, or *d*; but *c*, which is less weathered, shows a suggestion of shagreen towards the distal end of the adoral surface. In *e* the mid-rib bears a few small scattered pustules (fig. 411). In *g* there is slight ribbing at the distal end of the adoral side.

Relations of the species. — *Cidaris bicarinata* Klipst. differs from *Radiolus penna* in having a hollow shaft with vanes reduced to mere keels, which have little more effect than to give to a cróss-section of the shaft a sub-triangular outline (fig 434). *C. alata* in some of its forms comes nearer to *Radiolus penna*, but the mid-rib is not so sharply distinguished and there is more pronounced ornament. Without asserting that these radioles were borne by a species distinct from any to which a name has ever been applied, we may regard them as a well-defined type of radiole, at present incapable of reference to any known species.

«*Cidaris*» *trigona*.

(Plate XIII, figs. 413—416, and Plate XVII, fig. 452)

1841. *Cidaris trigona* Münster, Beitr. z. Petrefactenk. IV, p. 44, pl. iii, f. 15 *a*, *b*.
1848. *Cidaris imbricata* Cornalia, Notiz. geo-min. sopra alcune valli . . . d. Tirolo, p. 40, pl. iii, f. 4 *a—c*, *a'*.
1848. *Cidaris truncata* Cornalia, Notiz. geo-min. sopra alcune valli . . . d. Tirolo, p. 39, pl. iii, f. 3 *a*, *b*.
1855. *Cidaris trigona* Münst., J. Koechlin-Schlumberger, Bull. Soc. Geol. France (2), XII. p. 1063.
1865. *Cidaris trigona* Münst., G. C. Laube, Denkschr. Akad. Wiss. Wien, Math.-Nat. Cl. XXIV, Abth. 2, p. 285, pl. viii *b*, f. 6.
1875. *Cidaris trigonus* Münst., F. A. Quenstedt, Petrefactenk. Deutschlands, III, p. 196, pl. lxviii, f. 83—85.
1900. *Cidaris trigona* Münst., E. K. Hesse, N. Jahrb. Mineral., Beil.-Bd. xiii, p. 229.
1904. *Cidaris trigona* Münst., F. Broili, Palaeontogr. L, p. 156, pl. xvii, f. 42—44.

Diagnosis. — A Cidaroid in which the primary radioles have a coarse micro-structure of irregular prisms, running vertically in the axial complex, but bending outwards near the sides, and sealed on the surface by a thin cortex; the shaft has a short smooth handle, and massive blade thickening distalwards, with one flattened or concave face, and two other faces meeting in a rounded back; ornament usually imbricate on the flattened face but pustulate on the other faces; distal end swollen and separated from the sides by a distinct edge, sometimes raised in a rim; base relatively small, with smooth acetabular margin and annulus, and very low collerette.

Holotype. — Of the two specimens figured by Münster (1841, Taf. III, f. 15) and now in the Palaeontological Museum, Munich, the original of his f. 15 *b* is hereby selected as holotype.

Description of St. Cassian specimens. — Münster described the radioles as rare. Koechlin-Schlumberger had fifteen in his collection; the British Museum has fifteen from the Klipstein Collection (regd. 36486) and two from the J. E. Lee Collection (regd. E 1023). Other specimens are in most of the large collections. The species therefore is not among the rarest of Cassian forms.

The radiole consists of a massive shaft and a relatively small base.

The shaft consists of a stout ornamented blade, and a short smooth handle tapering rapidly towards the base.

The blade of the shaft increases equably in diameter from the handle to the distal end or crown It was described by Münster as very triangular, and this has been interpreted (e g. by Schlumberger) to refer to the cross-section. Laube (1865) also described the cross-section as markedly three-sided, usually with the form of an acute isosceles triangle, and sometimes extended in a vane on the acute angle. I have never seen a section of this form, nor has one been figured. Schlumberger said that the section might have one straight side and a rounded back, and this is the shape of the section figured by Münster. It is in fact the usual shape, and the variation mainly consists in the greater or less elevation of the back, and in the slight concavity of the flattened face. Increase of the concavity and depression of the back would perhaps produce the flattened symmetrically bicarinate form also mentioned by Schlumberger and compared by him with *C. alata*; but I have never seen a form that really resembled that species. The flattened side was probably in the transverse plane, and comparison with other species, such as *C. alata* or *Anaulocidaris* leads one to regard it as the adapical face. Quenstedt, however (1875), seems to have taken the peculiar view that one of its margins was uppermost. The occasional concavity of this face suggests that it received the rounded back of the adjoining radiole, whether the one above it (as I suppose) or below it. Such a rational interpretation is not permitted by Quenstedt's orientation. The outline of this side may be compared to an isosceles triangle, with apex below varyingly truncate by the handle, and with base concave upwards where it meets the crown. Its margins are generally sharp, but scarcely carinate, and occasionally one may be truncate, probably where it abutted on an adjoining radiole at the side. The section of the shaft may be bilaterally symmetrical, but often one slope is longer or flatter than the other.

The distal end of the shaft forms a distinct crown, gently swollen, usually highest at about one-third of the distance from the rounded back, and always sloping more steeply to the back; it meets the sides of the radiole usually in a clear-cut angle, particularly the flattened side, and the edge of the angle may be raised in a slight rim.

The ornament of the shaft is variable, but it has a character of its own and the variations are not so haphazard as Schlumberger maintained. Taking as the simplest, though not necessarily the primitive form, a surface irregularly but closely strewn with small rounded granules like those common in *C. dorsata*, we note that such an ornament rarely, or (*pace* Schlumberger) never, covers the whole surface. There is a tendency for these granules to lie in transverse rows, and this is more marked on the flattened face Even where least obvious, the tendency can still be detected in the proximal region of that face. Usually the granules in the proximal rows on that face run together so as to form transverse ridges, and these may become so marked as to produce an imbrication directed distalwards. This imbrication may cover the whole flattened face, and in a few instances may also be developed to a less degree in the proximal region of the other faces. In the most pronounced forms the constituent granules are entirely merged and lost in the imbricating ridges, but as the ridges pass over the margins of the flattened face they are continuous with the lines of granules on the sides. In the British Museum specimens, at any rate, the imbrication is most marked and most extensive in the smallest radioles, but appears to change into transverse rows of granules in the larger ones, till, in the largest of all, the ornament is merely irregular granulation, except for the trace of imbrication at the proximal end of the flattened face. These facts suggests that the imbrication may, so far as this species is concerned, be more primitive than the granulation. A more minute account of it will therefore be given in connection with the micro-structure of the shaft.

QUENSTEDT seems to have found the granulation finer on the distal crown. This is not confirmed by the British Museum specimens, which show the granules there as generally less equal in size, and less regular in distribution. Perhaps QUENSTEDT only meant to imply, what is certainly the case, that the end-crown is always granulate, never imbricate.

QUENSTEDT also drew attention to the longitudinal grooves sometimes seen on the back of the shaft at its extreme proximal end. These may be due partly to vertical concrescence of granules, partly to weathering, partly to the action of boring parasites.

The handle is separated from the shaft by the proximal imbricate ridge, or by a distinct encircling line of granules. Its surface is smooth, but in exceptionally well-preserved specimens a faint longitudinal striation can be detected. It slopes suddenly to the relatively small base, the axis of which does not coincide with the central axis of the shaft but is nearer to the back, and often also nearer to one of the sides; thus the slope of the handle is gentlest towards the flattened face.

The collerette is separated from the handle by a slight step or faint ridge; it is very low, and appears only as a shallow groove above the annulus.

The annulus is gently rounded, smooth, and not prominent. No previous writer has been able to confirm MÜNSTER's description of it as finely crenelate; perhaps he alluded to the fine striation mentioned above.

From the annulus the base slopes in a concavo-convex curve to the slightly raised, smooth, marginal rim of the acetabulum.

The following are measurements of selected specimens in millimetres:

Greatest length . .	6·0	7·4	8·7	11·4	12·5	13·3	14·0	16·1	16·6	17·0	18·2	20·2
» sagittal diam. .	2·3	2·5	3·9	4·3	4·1	8·2	5·2	7·1	8·2	6·3	7·6	9·4
» transverse diam.	3·6	4·0	6·2	5·8	6·4	9·3	7·8	10·8	10·5	9·5	11·9	12·3
Length of flattened face	4·7	6·2	6·8	8·8	10·5	9·7	11·8	ca. 10·8	11·4	12·8	13·5	16·0
From acetabulum to distal end of handle	1.2	?	1·8	2·0	1·8	?	?	2·2	2·6	2·5	3·5	3·2
From acetabulum to top of collerette .	0·3	?	0·8	0·9	?	?	?	1·2	1·2	1·2	1·5	0·9
Diameter of annulus	0·6	?	1·15	1·3	1·1	?	?	2·6	1·9	2·3	2·8	1·8

In taking these measurements the flattened side has been regarded as vertical. The ratio of sagittal diameter to length varies from 0·32 to 0·61, and these extremes occur together near the middle of the series; their mean is 0·47, and the average is 0·42. The ratio of transverse diameter to length varies from 0·5 to 0·71, and these extremes also occur close together; their mean is 0·6 and the average is 0·59. The ratio of the total height of the base to the diameter of the annulus varies from 0·46 to 0·69, the mean being 0·57, and the average 0·56.

The Micro-structure has been briefly described by HESSE (1900, p. 229) in conjunction with that of *Cidaris Waechteri.* There is really considerable difference between the two; in fact that of *C. trigona* is exceedingly peculiar, so much so that one can scarcely recognise a cross-section as representing an Echinoid radiole (Plate XVII, fig. 452). The axial complex occupies a very large part of the cross-section, about two-thirds of the total diameter. It consists of thin-walled polygonal meshes, irregular in shape and size, but usually large. Towards the periphery, the walls of these meshes merge into rather thicker, widely but irregularly spaced, radiating septa, sometimes dichotomous, and joined by a few thin trabeculae at irregular intervals. At the extreme circumference the septa thicken suddenly and are united by an outer layer, which is of about the same thickness as the inner parts of the septa, but thickens to form the pustules of the surface.

The septate layer is not always equally developed all round, but on the flattened face of the shaft can often scarcely be distinguished from the polygons of the axial complex. The appearances remind one of a section across one of the Palaeozoic Trepostomatous Bryozoa, such as *Diplotrypa*, so much so that I laid aside as useless the first thin section that was made, supposing the radiole to have been invaded and in great part absorbed by some encrusting Bryozoon or Hydrozoon. Further examination of sections and weathered surfaces at last permitted the following interpretation. The whole mass of the shaft is composed of prismatic tubes, between which others arise at irregular intervals. These tubes are traversed at unequal distances by trabeculae or by cross-partitions, sometimes flat, sometimes curved. Around the main axis, and towards the flattened face of the shaft, the tubes approach a vertical position, but the outer ones gradually bend over till their ends lie at right angles to the outer face of the sides and back of the shaft. Here they are sealed by the thin pustulate cortex.

Applying these facts to those already learned about the surface ornament, we infer that in the younger radioles the prisms are nearer the vertical throughout, and the high angle at which they strike the outer surface tends to produce an imbricate ornament. This is most obvious on the flattened face, where it persists longest, so that examination of this face with a strong lens (× 16) reveals the almost vertical walls of the prisms, forming pillars between the imbricate lines of their outcropping ends; between the pillars may also be seen occasional cross-partitions or trabeculae. Whatever may be the case on the sides of the shaft, the prisms always strike the distal crown more or less at right angles, so that the ornament there is never imbricate. The similarity to a massive Bryozoon stock is thus seen to govern the whole structure of the shaft, except for the fact that on the surface the prismatic tubules are closed by a cortex.

The section is obscured in parts by agglomerations of small, densely black, round grains, lying within the meshes; these may represent the carbonised remains of the stroma, which was of course greatly in excess of the stereom in such a form.

Specimens from the Pachycardientuffe. — Broili (1903, p. 156) has found the radioles fairly abundant in this formation at the Seiser Alp. Their average size seems to be smaller, and the distal end is frequently either broken or rugose. They may represent a slight mutation, but the adherent matrix prevents close examination of the ornament, and no further differences are discernible either in the specimens at Munich or the two in the British Museum (E 4699). The chief measurements of the latter are: greatest length, 8·7 and 11·5 mm.; greatest sagittal diameter 4·7 and 5·2 mm.; greatest transverse diameter, 5·4 and 7·3 mm.

Material from Bakony. — The Cassian bed *e* 4 of Section VI, Veszprém, has yielded two small specimens (Plate XIII, figs. 413—416). In both the distal end is more truncate than I have observed in any Cassian specimens. The smaller of the two (figs. 413—415), which is the better preserved, has a flattened, concave, face of relatively greater width than any Cassian specimen, and in this respect contrasts still more with those from the Pachycardientuffe. On this face are seen the vertical walls of the prismatic tubes, but there is no imbrication. On the back the pustules are in distinct longitudinal rows. In the larger specimen the flattened face is obscured by matrix, and on the back (fig. 416) the pustules are coarser and irregular.

The following are measurements in millimetres:

Greatest length	4·6	6·0
Greatest sagittal diameter	2·0	3·0
Greatest transverse diameter	3·9	4·0
Length of flattened face	3·5	4·8
Length from acetabulum to distal end of handle	1·3	1·1
Length from acetabulum to top of collerette .	0·4	0·7
Diameter of annulus	0·8	1·5

Thus the ratio of greatest width to greatest length is 0·84 and 0·66.

It is possible that these Bakony specimens represent a local variety or a mutation; but till other specimens have been found with a similar structure, it would not be wise to propose a new name.

Relations of the species. — Laube was doubtless correct in referring to *Cidaris trigona* the radioles on which Cornalia (1848) based his *C. imbricata* and *C. truncata*. These are quite characteristic of the larger and smaller sizes respectively. In Cornalia's fig. 3*b*, the imbrication of the concave face in *C. truncata* is much closer than in equal-sized specimens of *C. trigona*; but, to judge from his description, the closeness is greatly exaggerated in the figure.

Koechlin-Schlumberger (1855) regarded *Cidaris trigona* as only a variety of *C. dorsata*. We have already seen that the complete series of *C dorsata*, whether from youth to age or from adoral to adapical, runs on other lines than those followed by the series of *C. trigona*. Apart from this, the micro-structure of the two forms is perfectly distinct.

Quenstedt (1875), while maintaining the species, placed it next his *Radiolus crumena* (p. 195) of similar colour and appearance. The unique holotype of that species, in the Geological Museum, Tübingen, owes much of its peculiar shape to crushing; adapical radioles of *C. dorsata* may have a similar ridge round the distal end, and it is probably one of them.

Next to *C. trigona*, QUENSTEDT (1875, p. 196), described his *Radiolus complanatus*, previously confused with *C. Roemeri* Although subsequent authors, including QUENSTEDT himself (Handbuch d. Petrefactenk., 1885), have paid no attention to this species, examination of the 166 specimens in the British Museum has convinced me that QUENSTEDT was right in separating it. It is this species that seems most closely allied to *C. trigona*, since it has the same massive shaft, with one face flattened and imbricate, the others rounded and granulate. The differences between the two lie in the greater average size of *R. complanatus*, the general smoothness of its back, and the angle formed by the axes of the handle and blade. *Cidaris Roemeri* is easily distinguished from *R. complanatus*, but into that question we cannot enter now. It has, however, the imbricate ornament of *C. trigona* and *R. complanatus*, only intensified, and we may here recall QUENSTEDT's comparison of its shaft to a massive Bryozoon. Considering these resemblances, it is the more curious to find that neither *R. complanatus* nor *C. Roemeri* has the very coarse micro-structure of *C. trigona*. In *R. complanatus* the septa fork more than in *C. trigona*, and are twice or three times as close (Pl. XVIII, fig. 454). In *C. Roemeri* the septa not only fork, but wave and anastomose; and the structure is fully six times as fine as in *C. trigona* (Pl. XVIII, fig. 455, 456).

Cidaris tyrolensis DESOR (1855, p. 20, pl. ii, f. 7) was referred by LAUBE to *C. Roemeri*. The original of DESOR's f. 7*a* probably belongs to *C. Roemeri* s. str., and the original of his f. 7*b* probably belongs to *Radiolus complanatus*. To avoid confusion of nomenclature, I hereby select the original of MÜNSTER, 1841, pl. iv, f. 3, *e* as holotype of *Cidaris Roemeri* WISSMANN in MÜNST.; the original of QUENSTEDT, 1875, pl. lxviii, f. 87 *a, b, c* as holotype of *Radiolus complanatus* QUENST.; and the original of DESOR 1855, pl. ii, f. 7*a* (= MÜNSTER 1841, pl. iv. f. 3, *h*) as holotype of *Cidaris tyrolensis* DES. Thus *C. tyrolensis* becomes a synonym of *C. Roemeri*, and the name *R. complanatus* is not interfered with.

Another species that seems to fall into the same group as *C. trigona* is *Cidaris Petersi* LAUBE (1865, p. 284, pl. viii *b*, f. 5), of which I have examined the two syntypes at Vienna. The original of LAUBE's f. 5*a* is hereby selected as holotype.

The ornament of this species resembles the imbricate ornament of *C. trigona*, and in the holotype merges into pustules at the distal end; the difference is that the microstructure, as judged from external examination, is finer. Other resemblances are found in the small acetabulum with smooth margin, the smooth annulus, and the very short collerette.

In its ornament, this group of species (*C. trigona, C. Roemeri, C. Petersi*, and *R. complanatus*) approaches the group of *C. flexuosa* and its allies; but that group differs in having a large axial canal instead of a loose axial complex. The internal structure of *C. Petersi*, however, is still unknown.

Diadematoid Radioles.

Although Hesse (1900) has described all the Cassian radioles as modifications of the *Cidaris* type, this cannot be taken to mean that all belong to genera of Cidaroida; in fact the radioles of such admitted Diademoids as *Acrosalenia* and *Hemicidaris* are also of the *Cidaris* type, and the radiole of *Diademopsis Heeri* from the Lower Lias is described by Hesse (1900, p. 250) as approaching the *Cidaris* type in many respects, notably in having no axial canal, but an axial complex merging into the radiate septa. Now, certain of the Cassian radioles seem to be much closer to the normal *Diadema* type than do any of these; they have a large axial lumen, separated by a distinct layer (the «Axialscheide» of Hesse) from the outer layer of radiate septa. The septa, too, are more regular and stouter than is usual in the Cassian Cidaroids, and crop out on the surface so as to produce a clear and regular linear ornament. The cross-section of *Cidaris flexuosa* as represented by Hesse (1900, p. 231, f. 2) serves as a general diagram of this type of structure, though in the section of that species now before me the trabeculae seem to alternate in position and the septa to bend in slight zigzag fashion from one trabecula to another, so that the enclosed meshes form radiating series of elongate hexagons. Further, I should not describe the cortex as «not preserved», but as «non-existent», at least over the greater part of the shaft.

To this type of structure we have already recognised a tendency, either in the apparent resorption of the axial complex, or in the definite connection of the outer longitudinal ornament with the vertical radiate septa; and it may well be that some of the species hitherto described were not true Cidaroida. At any rate it seems most probable that those now to be discussed represent primitive Diademoida.

To the Cassian species of this group the following names have been applied: *Cidaris flexuosa* Münst. (1841, p. 44), *C. cingulata* Münst. (1841, p. 44), *C. linearis* Münst. (1841, p. 45), *C. Brandis* Klipst. (1845, p. 269), *C. Meyeri* Klipst. (1845, p. 270), *C. bicarinata* Klipst. (1845, p. 272), and perhaps *C. Petersi* Laube (1865, p. 284) and *C. undulatus* Quenst. (1875, p. 199). All these, except the last, agree in possessing a distinct longitudinal striation; and this, in the type-specimens of *C. flexuosa*, *C. cingulata*, *C. Brandis*, and *C. Petersi*, is traversed at right angles or obliquely by coarser ridges, which are absent from the type-specimens of *Cidaris linearis*, *C. Meyeri*, and *C. bicarinata*. The former species may therefore be considered first.

Between *C. cingulata* and *C. flexuosa* the only difference that can be gathered from Münster's diagnoses is that in the former the cross-ridges are «in ziemlicher Entfernung». but «sehr nahe stehende» in the latter. Measurements are not given, but one learns from Münster's figure that in *C. cingulata* the ridges were at most 0.84 mm. apart. In undoubted specimens of *C. flexuosa* before me [B. M. 36488, and 36510] the distance varies from 0·7 to 0·8 mm. Laube therefore was doubtless justified in merging the two forms under one name; he chose the name *C. flexuosa*, that being the better established species, and although this name succeeds *C. cingulata* on Münster's page 44, any attempt to reverse Laube's choice would be harmful and unnecessary.

The next species, *Cidaris Brandis*, is also made by LAUBE a synonym of *C. flexuosa*, and examination of KLIPSTEIN's type material (B. M. 36527) leads me to confirm his action. In *C. Petersi*, however, LAUBE himself has founded a species which seems remarkably close to *C. flexuosa* as thus extended by him. As in the original specimens of *C. Brandis* (B. M. 36527), the cross-ridges are regular, almost horizontal, and not wavy. The body of the radiole is wider, larger, and thicker than in the type-specimens of *C. flexuosa*, and spreads out more rapidly from the annulus; but all these features are seen, though less pronounced, in *C. Brandis*. The margin of the acetabulum is said by LAUBE to be quite smooth; but there are traces of crenelation, at all events in the smaller of the two syntypes. The remaining feature is the presence of tubercles at the distal end; these, however, may, as recognised by MÜNSTER (p. 45), occur in *C. flexuosa*.

It seems probable that the four forms to which the names *cingulata*, *flexuosa*, *Brandis*, and *Petersi* have been applied represent respectively the adoral, ambital, adapical, and apical radioles of a single species, to which *C. undulata* may also belong. This species, for which the name «*Cidaris*» *flexuosa* should be maintained, is distinguished by longitudinal striation, combined on the shaft with transverse ridging, and by the minute structure already described, of which the essential features are regular radiate septa and a wide lumen occupying about 0·64 of the diameter of the shaft. The last character has, it is true, not been proved for the form called *C. Petersi*, but of it only two specimens are known (vide antea, p. 224).

We turn now to *C. linearis*, *C. Meyeri*, and *C. bicarinata*. LAUBE was of opinion that *C. Meyeri* (which he mis-spelled *Mayeri*) differed from *C. flexuosa* «nur durch die etwas spitzere Form»; but neither he nor HESSE, who followed his synonymy and his spelling, saw KLIPSTEIN's specimens of *C. Meyeri* or adduced any evidence in support of his opinion. KLIPSTEIN's MS. list of specimens sold to the British Museum mentions four specimens under «No. 652, *Cidaris Meyeri*». There are, however, four specimens now associated with the holotype, making five in all, and registered as 36496 *a—e*. The locality of the first specimen found (probably the holotype) was Set Sass; the others came from the Campillberge. The various specimens of *C. flexuosa* that I have seen are assigned merely to St. Cassian. Examination of KLIPSTEIN's specimens of *C Meyeri* reveals the following differences from *C. flexuosa*. The longitudinal striation is twice as fine and has not the transverse ridges so characteristic of *C. flexuosa*, the «Querzeichnungen» mentioned by KLIPSTEIN being for the most part bands of colour, which are seen only in the holotype, together with a prominent ring probably due to repair of the radiole during life. The general shape, small base, low and smooth annulus, and short collerette, all distinguish this form from *C. flexuosa*; but above all is the fact that no specimen of *C. Meyeri* possesses the wide lumen and thin wall of that species. The rarity of *C. Meyeri* and the rather poor state of preservation of its representatives throw doubt on its specific independence; but if it is to be referred to any species, it must be to *C. linearis*, which it approaches in general shape and ornament. From authoritative specimens of that species, however, it differs in the smaller base, the non-projecting annulus, the clearly marked collerette, the cigar-like shape, and the relative fineness of the longitudinal striation. The lumen of *C. linearis* (Pl. XIII, figs. 433, 434) is wider than that of *C. Meyeri*, although not so wide as that of *C. flexuosa*; the specimen figured by KLIPSTEIN, pl. xviii, f. 13 (Brit. Mus. 36511) has a wider lumen than usual in the species, and has in consequence been flattened. Differences of lumen within the limits of one species may perhaps be correlated with different positions on the test; certainly, as between different species, the wider lumen is associated with the more pronounced ornament, and, since this ornament arises out of the internal structure of the stereom (Pl. XVII, fig. 453), it is pretty clear that this association depends on the greater strength of the coarse striation, especially when enhanced by a cross-ribbing. However this may be, the time has not yet come for the suppression of *C. Meyeri*.

With *C. bicarinata* it is another matter. Fresh evidence supports LAUBE's reference of this to *C. linearis*, although it must be admitted that he was not justified in making such a reference without examination of the holotype, and further that such examination might well have made him hesitate. The specimen figured by KLIPSTEIN (pl. xviii, f. 11) is No. 658 of his collection (B. M. 36502); its shaft bears no trace of longitudinal striae; in transverse section (fig. 434) one side of its shaft forms a curve of about 4 mm. radius, but with a tendency to a median angle, the other side a curve of about 1 mm. radius; where the two curves meet on each side is a slight keel that dies away at the proximal end of the shaft; there is a wide subcircular lumen filled with secondary calcite; the shaft is separated from the collerette by a slight but obvious ridge or terrace, which curves downwards so as to approach the annulus on the flattened side; the collerette is longitudinally striate, the annulus finely crenelate, and the acetabular margin smooth. This differs from *C. linearis* as diagnosed by MÜNSTER and by LAUBE in the absence of striae from the shaft, the presence of side-keels, the ridge defining the collerette, which is relatively long (LAUBE says of *C linearis* «collis brevis» and «sie gar keinen Hals hat»), the crenelation of the annulus, and the smoothness of the acetabulum. Very little weight is to be attached to the last two characters, and undoubted specimens of *C. linearis* vary in these respects. The few fragments of *C. bicarinata* which LAUBE had for study * must, one supposes, have shown the longitudinal striation or he would have noted its absence; at any rate the only other specimen in the British Museum (E 8535), a short fragment from St. Cassian, shows it plainly all over. On the other hand, this same fragment, though it appears to retain a portion of the base, has no trace of a collerette. In radioles that have longitudinal striae on the collerette but not on the shaft, it is relatively easy to distinguish the collerette; but in this species the limit between collerette and shaft is constituted only by the slight terrace, which marks the distal edge of the integument, and is only formed if that remains a sufficient time at the same level. The differences between *C. linearis* and *C. bicarinata* are therefore reduced to the flattened face and the slight lateral keels of the latter. The rarity of the bicarinate form is in itself an argument against its specific independence, and the evidence of the St. Cassian material would alone incline one to accept LAUBE's action. Fortunately, strong confirmation is afforded by the Bakony specimens of a closely allied species, which is represented by cylindrical, compressed, and bicarinate forms associated at the various localities, some with and some without a collerette.

Thus the seven or eight names with which this investigation began have been

* Probably his pl. x, f. 10 *b* represents one of these; a transverse section of it is represented on our Plate XIII, fig. 433.

assigned to two undoubted species, for which are retained MÜNSTER's names *C. flexuosa* and *C. linearis*, and one doubtful species *C. Meyeri* KLIPST., possibly a synonym of *C. linearis*.

It is, however, necessary to allude also to *C. biformis* MÜNST., a species based on a few fragments. The proximal striated portion is obviously the collerette; in other words the radioles have a very long collerette, a fact suggesting that they are not fully grown. The small fragment of the distal portion, or shaft, suggests affinity or identity with such a form as *C. similis*, while the collerette, taken by itself, might be mistaken for *C. linearis*. «So, dass», as MÜNSTER says, «einzelne Bruchstücke zu zwei verschiedenen Arten zu gehören scheinen». It seems to me, however, that *C. biformis* is merely the young of some other species, and that, in their attempts to recognise it, subsequent authors have referred to it fragments of the two species just mentioned. Thus of the three radioles associated with KLIPSTEIN's label «No. 636, *C. biformis*», one [E 4683] is undoubtedly *C. linearis*, another [E 4684] appears to be *C. similis*, and the third [36485] reminds one most of KLIPSTEIN's own *C. Meyeri*. In this last specimen the base is rounded, approaching a hemisphere, with the acetabular margin raised in a ring which may have been crenelate, but is obscured by weathering; the smooth annulus is followed by a very low collerette, distinctly separated from the shaft and marked with fine longitudinal striae; the shaft, which is polished, perhaps by wear, is circular in section, and increases slightly in thickness before beginning to taper. The low, deeply sunk collerette proves that the specimen is not *C. biformis*, and it is curious that the same appearance should be so marked in LAUBE's figures 9 *a* and 9 *b* (Taf. x), especially as it cannot be distinguished in the specimens labelled as the originals of those figures. The axial hollow seen in the original of LAUBE's fig. 9 *b* is strong evidence for that specimen being *C. linearis*. The original of his fig. 9 *a*, which is 7·6 mm. long and 2·1 mm. thick in the widest part, probably belongs to the same species. Another specimen in the collection of the Austrian Geological Survey, labelled *C. biformis* by LAUBE, but not figured, has a distinct short collerette, only 2·5 mm. long, with a diameter of 2·4 mm., and thus does not agree with the diagnosis. The original of LAUBE's fig. 9 *c* and 9 *d* does not resemble MÜNSTER's figure, and although the fine tubercles in its distal portion may be held to differentiate it from *C. linearis*, still, as the material to be described from the Bakony district proves, this is undoubtedly a possible variation of the *linearis* type. The conclusion as to *C. biformis* therefore is that the species is invalid, having been based on an immature radiole, probably of *C. similis* or *C. Wissmanni*, and that the specimens subsequently referred to it belong either to those species or to *C. linearis*.

Among Raiblian radioles hitherto described the only one that seems connected with this group is the holotype of *Cidaris Schwageri* WÖHRMANN (1889, p. 194, pl. v, f. 16) from the Cardita-Oolith of Rammelsbach near Seehaus, and now in the Palaeontological Museum, Munich. Having been very kindly entrusted with this for study, I take the opportunity of giving an enlarged drawing (Pl. XIII, fig. 417) as well as a further enlargement of the ornament (fig. 418). This consists of longitudinal striae (or fine ridges), separated by deep narrow grooves, and with rounded edges obscurely divided by unequally spaced transverse depressions. In the proximal, stouter, region of the radiole, these ridges run about 14 to 1 mm.; nearer the distal end of the fragment they are 16 or a little more to 1 mm. They are therefore both coarser and more distinct than in *C. linearis.* The broken end of the radiole is not easily seen, but it is plain that the ridges are the outer edges of stout wedge-shaped radiate septa. A dark iron-stained spot in the centre of the broken end, suggests the former presence of a relatively narrow lumen. The base is rather massive and elongate, with rounded smooth annulus, no sign of a collerette, wide acetabulum with raised, obscurely crenelate margin. Total length of fragment 2·5 mm. Diameter at annulus 0·62 mm. WÖHRMANN describes the shaft as «oben und unten von gleicher Stärke», but draws it as thinner in the middle region; really it tapers from the annulus towards the broken end.

To this species WÖHRMANN provisionally referred some interambulacrals found in the same rock. His figure (pl. v, f. 17), which shows two of them, did not lead me to suppose that they belonged to any species found in Bakony, but examination of the original specimen now proves it to belong to the form already described (p. 118) as *Mesodiadema latum.* The fragment (Pl. XIII, fig. 419) comprises five interambulacrals in association, and shows the great transverse width of the plates and the characteristic curve of their upper and lower margins, features by no means obvious in WÖHRMANN's figure.

The radiole on which *Cidaris Schwageri* was founded is no doubt that of a Diadematoid, and it may have belonged to *Mesodiadema latum.* Were that proved, the latter species would be called *Mesodiadema Schwageri.* But the supposition is not proved, and the fact that the radiole *C. Schwageri* has not been found in those Bakony localities that have yielded *Mesodiadema latum* goes far to discredit it.

Turning to the Bakony material, it is rather strange to find no representative of *C. flexuosa;* on the other hand, radioles superficially resembling *C. linearis,* and in a less degree *C. Schwageri,* are abundant.

Setting aside a possible radiole of *C. Meyeri,* one can divide the rest into two groups according to size. Size of itself is not generally regarded as differentiating species; but when the specimens all occur in the same localities and beds, and when there is a notable absence of sizes intermediate between the large and the small, it is impossible to ascribe the difference to age, to environment, or to nutrition, or indeed to anything except specific or varietal character. It is also noteworthy that, although the larger radioles may be compressed, still the distinctly bicarinate and muricate forms mentioned above appear as developments of the smaller size alone; and this militates against the supposition that the smaller radioles are merely secondary ones. All these radioles might perhaps be regarded as varieties of *C. linearis* with lesser individual variations; but this would leave out of account the microstructure and the size of the longitudinal striae. The lumen also, as will be seen from the accompanying table (p. 230) is generally narrower in the Bakony radioles than in those of *C. linearis* of St. Cassian. Therefore, to avoid a row of subspecific and varietal names, it is well to give the former a distinct name to which varietal names can then be affixed. Grouping all under the new name *C. lineola,* we distinguish var. *major* and *minor,* the latter having its bicarinate and muricate forms, for which Latin names are not required.

Comparison of Striation and Lumen.

	Striae to 1 mm.	Lumen
C. flexuosa, specimen figd. KLIPSTEIN [B. M. 36510] .	12	large
C. linearis, specimen figd. KLIPSTEIN [B. M. 36511] .	20	large
C. linearis, KLIPSTEIN Colln. 636 [B. M. E 4683] . .	18	medium sized
C. Meyeri, holotype [B. M. 36496 *a*]	24	small
C. Schwageri, holotype [Pal. Mus. München] . . .	14—16	apparently small
R. lineola major, thin section from Jeruzsálemhegy . .	24—28	rather large
R. lineola minor, thin section from Quarry near Cutting I	16—18	rather small

By «large» is meant a lumen more than half the diameter of the shaft; by «small» is meant a lumen less than one-quarter the diameter of the shaft.

Radiolus lineola n. sp.

Diagnosis. — Radioles with elongate shaft, cylindrical, or compressed dorso-ventrally, or bicarinate; with medium-sized axial lumen, surrounded by a dense layer of exceedingly fine, waving and inosculating septa, which, as they radiate to the periphery, thicken and become regular; with surface usually plain, but sometimes bearing small irregularly placed pustules, and always marked by fine longitudinal striae (30—32 to 1 mm.), broken into pits by the interseptal trabeculae; the same striae pass over the collerette, which may or may not be separated from the shaft by either a ridge or a depression, and is usually wider than the shaft at its proximal end; annulus still further projecting, marked by striae and obscure crenellae; base conical-truncate, or with concave sides; acetabular margin a coarsely crenelate projecting ring.

Owing to the fragmentary nature of the material, proportional measurements cannot be given.

Holotype, the original of Pl. XIII, fig. 420, from the Raiblian of Jeruzsálemhegy; this is also the holotype of var. *major*. The species occurs in rocks of both Raiblian and Cassian age, at the localities mentioned under the varieties.

Description of Specimens. — As stated above, the radioles assigned to this species fall into two groups according to size, and bearing no obvious relation to either locality or horizon, though the larger ones have not yet been found in beds of Cassian age.

The number of specimens of the larger size is not enough to permit of the construction of graphic curves; still there is hardly reason to doubt the distinctness of the group. Taking the specimens associated at a single locality, e. g. Jeruzsálemhegy, we find that, out of 102 radioles, 24 have an average diameter of 2·55 mm., being almost equally distributed on either side of this number between the limits 1·85 mm. and 3·45 mm., of which the mean is 2·65 mm. The remainder have an average diameter of 1·04 mm., being unequally distributed so that three-quarters of them lie at or below 1·05 mm., between the limits 0·65 mm. and 1·69 mm., of which the mean is 1·17 mm. Of these, 15 are bicarinate; and if they be eliminated, the average becomes 0·96 mm. and the mean also 0·96 mm. Even with their retention, however, it is clear that the curve for the whole assemblage would be distinctly double-crested, and would in fact form two curves separated by a clear interval of about 1·75 mm. This justifies the erection, at least for descriptive purposes, of two varieties.

Radiolus lineola var. *major*.

(Plate XIII, figs. 420, 421, and Plate XVIII, fig. 457).

Diagnosis. — *Radiolus lineola* with mean diameter of radioles about 2·6 mm.; surface always smooth.

Holotype, the original of Pl. XIII, fig. 420, the same as the holotype of the species.

Material from Bakony. — Jeruzsálemhegy, 24 fragments; from Cutting I on the Veszprém-Jutas railroad, 5 fragments labelled bed *e*, and 11 with no horizon assigned. All these are Raiblian.

Description of Specimens. — These radioles are nearly all cylindrical or slightly compressed. Of bicarinate forms there are only two from Jeruzsálemhegy and one, rather doubtful, from Cutting I; and, since these are of small diameter (1·85 and 2·00 mm.) even in their greatest width, they might possibly be more correctly placed with var. *minor*.

The length of a complete radiole may be estimated from the fragments to have reached about 45 mm. The largest fragment with base is 16·8 mm.; one without base or any sign of tapering reaches 13·2 mm. In a radiole of 3·4 mm. diameter in the shaft, the diameter at the annulus is 4 mm., and at the beginning of the collerette 3·9 mm.; the height of the base to the top of the annulus is 2·5. In a radiole of 2·6 mm. diameter, the diameter at the annulus is 3·7 mm. The large annulus, tapering collerette, and straight-sided shaft, remind one of a jousting-lance, and are distinctive of the species among the Bakony radioles, though the shape is, of course, common to many Diademoida.

The microstructure is difficult to make out, owing partly to closeness of grain, partly to secondary calcite. When the axial lumen is filled with such calcite, it is hard to distinguish its limits in a thin section or to be quite sure that the irregular outlines and fractures of the imperfect crystals do not represent an axial complex. In a radiole of 2·7 mm. diameter, the width of the lumen is about 1·4 mm., the thickness of the wall thus being about one-quarter the diameter of the radiole.

The wall is composed of radiating septa, which can only be seen clearly in places (as represented by the darker patches in fig. 457). The evidence of the section figured and of another, also from Jeruzsálemhegy, suggests that the septa did not dichotomise as they do in most of the Cidaroid radioles, and, on the other hand, that they did not form solid wedges as they do in characteristic Diademoid radioles. Close to the lumen the septa seem to form a dense layer, showing to the naked eye or a simple lens as a dark band. This is not so definite as to be called an axial sheath, but may represent an incipient stage of that characteristic Diademoid structure

Radiolus lineola var. *minor*.

(Plate XIII, figs. 422—429, and Plate XVIII, fig. 458.)

Diagnosis. — *Radiolus lineola* with mean diameter of radioles about 1·1 mm.; surface often carinate, muricate, or pustulate.

Holotype, the original of Plate XIII, figs. 422—425, from the Raiblian of Quarry near Cutting I.

Material from Bakony. — Jeruzsálemhegy, 11 fragments with base, showing distinct collerette; 6 with base, showing no collerette; 46 with base indistinct or absent; 15 fragments of bicarinate form.

Veszprém-Jutas railroad, Cutting I, bed *e*, 1 radiole; horizon unrecorded, 12 radioles of normal type and 1 muricate. Quarry near Cutting I, 16 with bases, 32 without, and 1 muricate. Cutting IV, beds *a—b*, 1 fragment without base.

All the preceding are Raiblian.

Cassian beds of Cserhát (Leitnerhof), 32 of normal form, of which no less than 27 retain the base; also 12 muricate distally, with base preserved in 8. The contrast between the proportion of bases collected from these Cassian beds and that from the Raiblian is worth noting; it is not due to any better preservation of the radioles.

Description of Specimens. — The normal form of var. *minor* resembles var. *major*, but a larger proportion is compressed; and, in harmony with this, the proportion of the bicarinate form is also greater.

The longest fragment with base is 12 mm. long; the largest without base, 11 mm.; neither preserves the distal end. Probably these radioles attained a length of 20 mm. on the average. A radiole with shaft of 0·95 mm. diameter is 1·4 mm. thick at the annulus, and the height of the base to the top of the annulus is 0·9 mm. A shaft 1 mm. thick has an annulus of 1·3 mm., with height of base 0·8 mm., and height of collerette 0·5 mm. A shaft 1·05 mm. thick has an annulus of 1·75 mm., with height of base 1 mm. and of collerette, 0·6 mm. In a radiole of 1 mm. diameter, the diameter of the axial canal is 0·4 mm.; and in one of 0·95 mm. diameter, it is about 0·3 mm. Sometimes the relative width of the lumen seems to have been greater, but those specimens are usually so crushed that measurement is difficult.

The muricate form is represented in the material from all the important localities except Jeruzsálemhegy. The fragment from Cutting I is beautifully preserved, and is 10·5 mm. long, but has no base; it tapers slightly towards one end, which is presumably distal; the thorns are about 4 to the square millimetre, and in no definite order; each occupies about the width of two striae or circa 0·06 mm. (Pl. XIII, fig. 429), and has a distal rake. The fragment from the quarry near Cutting I is of the same character.

The specimens from Cserhát are not so clear. In one the thorns are more prominent, and like saw-teeth; in another they are elongate so as to form little ridges. Were it not for the axial lumen and the striation of the shaft, one might well refer these specimens to *C. Wissmanni;* but that species, as we have seen, has a different micro-structure. There is a closer resemblance to various radioles from the Lias, figured by Quenstedt (1875, pl. lxvii, ff. 11—19) as *Cidaris amaltheoides* and allies, but those have more numerous thorns.

The micro-structure has been studied in a radiole from the Quarry near Cutting I (Pl. XVIII, fig. 458). In this are seen only an axial lumen, with a diameter about one quarter that of the shaft, and a wall of radiate septa. The section is elliptical and the septa are much clearer near the long axis of the ellipse; here they are straight, thick, and almost wedge-shaped, but apparently perforate. They are united by trabeculae, which are rather stout in the adcentral region of the wall. At the sides of the ellipse, the septa follow a curved course, and, as they are followed to the other end of the ellipse, seem to merge into the trabeculae; or one may describe thc septa as arranged in two systems, those of one system cutting across the other, as in watch-turned engraving. A similar arrangement sometimes occurs in other forms of echinoderm stereom, and we have already noticed something of the sort in the trulliform radioles of *Anaulocidaris*. At the sides of the ellipse the boundary of the lumen is distinct, but it is not so at the ends.

In this section the coarser septa, where they crop out on the surface are about 16 to the millimetre; but in other radioles they seem to be about 20 to the millimetre (fig. 429), 25 (fig. 425), or even finer. It is, however, very difficult to calculate exact measurements on these rounded surfaces, and thin sections of this material are rarely clear enough to be of use.

Relations of the Species. — The general form, the striation, and the hollow lumen appear to characterize a long series of radioles from the beginning of the Muschelkalk, or earlier, to the end of the Lias. The plates of the test or other remains associated in several instances with such radioles prove that they cannot all be referred to a single species. The descriptions of the radioles hitherto published do not permit intelligible and distinct specific diagnoses to be based on those skeletal elements alone; an extension of Hesse's work is required; meanwhile we recognize as fresh characters of diagnostic value the relations of the axial canal or axial complex, and the size of the longitudinal striae. By these features *C. lineola* may be distinguished from superficially similar forms of Keuperian age. It is, however, very difficult to distinguish these radioles from those of *Cidaris grandaeva* Alberti (1834 ex Goldf. MS.) a species said to range almost right through the Muschelkalk. The general form and superficial characters of normal radioles of *C. grandaeva* as described and figured by Alberti (1834, p. 96) Schmid & Schleiden (1846, pl. iv, f. 8), Quenstedt (1852, p. 574, pl. xlviii, f. 33), Schauroth (1855, p. 529, pl. iii, f. 6), Desor (1858, p. 160), Alberti (1864, p. 54), and Quenstedt (1875, p. 158, pl. lxvii, ff. 102, 109, 115, ff. caet. excl.) agree with those of the normal *C. lineola*. Examination of four radiole-fragments of *C. grandaeva* borne on a small slab of Trochiten-Kalk from Crailsheim (Brit. Mus. E 8536) shows further resemblance as regards the two characters mentioned above. On three of the fragments the striae are from 30 to 32 to 1 mm., and in a transverse section of 1·2 mm. diameter there appears to be an axial canal of 0·4 mm. or one-third the shaft diameter. These numbers agree with some specimens of *C. lineola*. Hesse, however, after examining several radioles of *C. grandaeva* says (1900, p. 215) that their micro-structure is of the normal *Cidaris* type, a statement implying that the shaft possesses both an axial complex and a cortex (axialer Röhrencomplex und Deckschicht). The former of these at least would afford a point of distinction, and it may be that the occasional appearance of a lumen is due merely to the looser structure of the stereom. Having regard to this statement, and also to the fairly frequent occurrence in *C. lineola* of a collerette and of bicarinate and muricate forms, none of which have yet been described in undoubted *C. grandaeva*, it seems better to retain this Keuperian species distinct from the Conchylian, especially as its test is still uncertain.

Wöhrmann (1889, p. 195) compared with *Cidaris grandaeva* both the radiole and the interambulacrals referred by him to *C. Schwageri*. We have already seen that the striation of that radiole is far coarser than the striation in *C. grandaeva*, and in this Wöhrmann's holotype differs from the equal sized and somewhat similar *Radiolus lineola minor*. The interambulacral plates ascribed to *C. grandaeva* are said to have crenelate main tubercles, and probably belong to *Miocidaris*.

Wöhrmann's remark, however, suggests that *R. lineola minor* may have belonged to *Mesodiadema latum*. The two forms are found at precisely the same localities. This, however, is not proof, for some radioles have to be found for *Mesodiadema margaritatum* (p. 117). Possibly the smooth radioles belonged to one species of *Mesodiadema*, and the muricate or carinate radioles to the other. Some also may have belonged to *Hemipedina (Diademopsis) incipiens* (p. 124).

Till proof of any such relationship is forthcoming, the only safe proceeding is to describe the radioles separately, and to give them distinct names.

«*Cidaris*» *Meyeri*.

(Pl. XIII, figs. 430—432).

1845. *Cidaris Meyeri* A. v. Klipstein, Geol. Östlich. Alpen, p. 270, pl. xviii, f. 4 *a*, *b*.
1865. *Cidaris Mayeri* [sic] Klipst., syn. of *C. flexuosa* Münst., G. C. Laube, Denkschr. Akad. Wiss. Wien, Math.-Naturw. Cl. XXIV, Abth. 2, p. 290.
1900. *Cidaris Mayeri* [sic] Klipst., E. K. Hesse, Neues Jahrb. f. Min. Beil.-Bd. XIII, p. 231.

Diagnosis. — Peripheral or circumapical radioles with elongate shaft, circular in section, swelling gradually from the annulus to one-third or one half way down, then tapering gently to the distal end; solid, or with small axial lumen; surface smooth except for a delicate longitudinal striation (of circa 24 striae to 1 mm.) which is rarely preserved; base small; acetabular margin crenelate; annulus smooth, not projecting beyond proximal diameter of shaft; collerette short, marked with longitudinal striae which pass over the annulus. The length of the radiole (20—30 mm.) being taken as 100, the length of the base is 2·2 to 3·4, diameter of collar 7·6 to 8·8, greatest diameter of shaft 11 to 12.

The above diagnosis, with its measurements, is founded on the holotype, i. e. the specimen figured by Klipstein, and on the best of his paratypes. For discussion of these, see p. 226.

Material from Bakony. — A single specimen referable to this species comes from the Cassian of Section VI, Veszprém. It is the proximal half of a radiole, and is 11 mm. long. The complete radiole must have been cigar-shaped, but slightly compressed, with a flatter face on one side, which is almost straight, and a rounded face on the other side, which is bowed. The sagittal diameter at the thickest part of the shaft is 2 mm.; the transversal diameter 2·2 mm. A white, but speckled, central area in the cross-section may represent either a lumen or an axial complex of loose stereom. Its diameter is 0·7 mm., or one-third of the whole. On each side of the shaft are traces of longitudinal ribbing. The surface of the shaft is weathered and shows no longitudinal striae. The base is not quite perfect, but there is no doubt as to its having been remarkably small. The greatest diameter of the annulus is 0·7 mm. The height from the acetabulum to the top of the annulus was about 0·4 mm. The collerette is represented by a slight ridge immediately above the annulus.

ASTEROIDEA.

ORDER: PHANEROZONIA.

«*Astropecten*» *Pichleri*.

(Plate XIII, figs. 435—437.)

1889. *Astropecten Pichleri* S. von WÖHRMANN, Jahrb. geol. Reichsanst. Wien, XXXIX, p. 192, pl. v, f. 11.

Diagnosis (after VON WÖHRMANN). — Marginals and oculars closely beset on the outer edge with rounded pustules, which are more or less developed according to the position they occupy. Oculars cordiform.

The original specimens comprised two terminals or oculars and a few marginals from the Cardita-Oolith of the Gleirschthal, of Haller Salzberg, of Rammelsbach near Seehaus, and elsewhere.

Since Dr. von WOHRMANN did not indicate a holotype, I select the ocular from Rammelsbach, represented in his f. 11 *a*. It is in the Palaeontological Museum, Munich, and has been kindly lent to me for study, as well as the three other figured specimens.

The holotype is rather worn, but is more complete than the other ocular (f. 11), for in that the ventral half has been cleaved away. The measurements of these specimens in millimetres are:

	f. 11	f. 11*a*
length	2.6	2.4
width	3.1	3.1
thickness	—	1.8

Of the two marginals figured, that shown in f. 11*b* is 1·2 mm. thick; the original of f. 11*c* is 0·75 mm. thick.

Specimen from Bakony. — This is a single ocular or terminal plate, from the Cassian bed *e* 4 of Section VI, Veszprém. It is 4·4 mm. long, 4·3 mm. in greatest width, and 2·6 mm. in greatest thickness. The outline is triangular with truncate angles. The «heart-shaped» appearance is enhanced by the ventral groove, which is 0·9 mm. deep and 2·1 mm. in greatest width. The pustules of the dorsal surface, are, as in the original of WÖHRMANN's f. 11 most pronounced near the narrow end. The truncate angles of the wider end face ventral-wards and are excavated by a slight groove, presumably for the ligamentar attachment to adjacent marginals. A similar, but less distinct, groove marks the base of the ossicle. Consequently the wider end may be regarded as proximal. The groove bends upwards slightly at the distal end, but is not returned on the dorsal surface.

Relations of the species. — Although our specimen comes from a bed said to be at a lower horizon than the Cardita-Oolith, and although it is rather larger than the holotype, there can be little doubt as to its specific identity therewith. The holotype is relatively shorter than our specimen.

Closely similar oculars are, according to WÖHRMANN, found in the Rhaetic of Kothalpe.

From the large size of the holotype, which is exceeded by our specimen, WÖHRMANN concludes that the animal attained the size of the recent *Astropecten aurantiacus*. The marginals figured by him are, however, small in proportion to the ocular, and so great a size cannot be inferred from the latter ossicle alone. In the Kimmeridgian *Astropecten elegans* E. FRAAS (1886), for instance, the ocular is quite as large as the holotype of *A. Pichleri*, but R is only 35 mm.

There is, of course, no particular reason why these ossicles should be referred to *Astropecten*, but, till further evidence is forthcoming, this name will serve as well as another.

This completes the Systematic Description of the Triassic Echinoderms of Bakony. The results obtained are analysed in the following Tables.

CRINOIDEA	MUSCHELKALK				CASSIAN						RAIBLIAN						
	Felsőörs	Vászoly, Ágasmagas	Tamáshegy	Alsódörgicse, Hangyas-Erdő	Cserhát, Leitnerhof	Veszprém, Section VI	Veszprém, Csősz-Domb	Veszprém, Takarékpénztár	Veszprém, Section XI	Giricses-domb	Jeruzsálemhegy	Veszprém Jutas Ry., Cutting I	Veszprém-Jutas, Quarry near Cutting I	Veszprém-Jutas Ry., Cutting IV	Veszprém, Lánczi	Veszprém, Kőképalja, Section VII	Total Number of Specimens
Encrinus cassianus . .	—	—	—	—	12	—	—	—	—	2	—	—	—	—	—	—	14
Encrinus granulosus . .	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
Encrinus cancellistriatus .	—	—	—	—	52	2	—	—	—	6	—	—	—	—	—	—	60
Encrinus sp.	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
Encrinus sp.	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Entrochus silesiacus . .	—	—	—	1	—	—	—	—	—	—	—	—	—		—	—	1
Entrochus sp.	—	—	—	—	3	—	—	—	—		—	—	—	—	—	—	3
Trochita sp . . .	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
Entrochus sp.	—	—	—	—	3	1	—	—	—	—	—	—	—	—	—	—	4
Trochita sp.	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Dadocrinus ?, sp. . . .	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
Entrochus quinqueradiatus	—	—	—	—	8	—	—	—	—	—	—	—	—	—	—	—	8
Holocrinus sp.	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Entrochus cf. Pentacrinus venustus	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	10
Isocrinus tyrolensis major	—	—	—	—	—	—	—	—	—	—	12	10	16	—	—	—	38
" " *var. α*	—	—	—	—	—	—	—	—	—	—	2	2	2	—	—	—	6
" " *var. β*	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
" " *var. γ*	—	—	—	—	—	—	—	—	—	—	—	—	—	8	—	—	8
" *candelabrum* .	—	—	—	—	16	1	—	—	—	4	1?	—	—	—	—	—	22
" *scipio*	—	—	—	—	473	1	—	—	—	22	—	—	—	—	—	—	496
" *sceptrum* . .	—	—	—	—	—	7863	4	—	—	1	—	—	—	—	—	—	7868
" *Hercuniae* . .	—	—	—	—	3?	—	—	—	—	—	47	10	400	—	1	1	462
" *sp.*	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
" " patina .	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
" " brachial .	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
Number of Species and Varieties, about 23	1	1	3	1	586	7868	4	—	—	35	62	23	418	8	1	1	9012

ECHINOIDEA TESTS	CASSIAN						RAIBLIAN						
	Cserhát, Leitnerhof	Veszprém, Section VI	Veszprém, Csősz-Domb	Veszprém, Takarékpénztár	Veszprém, Section XI	Giricses-domb	Jeruzsálemhegy	Veszprém-Jutas Ry., Cutting I	Veszprém-Jutas, Quarry near Cutting I	Veszprém-Jutas Ry., Cutting IV	Veszprém, Lánczi	Veszprém, Kőképalja, Section VII	Total Number of Specimens
Tiarechinus ? sp.	1	—	—	—	—	—	—	—	—	—	—	—	1
Triadocidaris persimilis	23	1	—	—	—	3	—	—	—	—	—	—	27
Triadocidaris sp. α	—	1	—	—	—	—	—	—	—	—	—	—	1
Triadocidaris praeternobilis	—	—	—	—	—	—	1	1	—	—	—	—	2
Triadocidaris ?, cf. *praeternobilis*	—	—	—	—	—	—	3	–	—	—	—	—	3
Triadocidaris cf. *subnobilis* ?	—	—	—	—	—	—	--	—	—	1	—	—	1
Triadocidaris immunita	—	—	—	—	—	—	5	—	—	1	—	—	6
Miocidaris ?, *sp. α*	2	—	—	—	—	—	—	—	—	—	—	—	2
Miocidaris sp. β	1	—	—	—	—	—	—	—	—	—	—	—	1
Miocidaris verrucosus	—	—	—	—	—	—	1	1	—	—	—	—	2
Miocidaris planus	—	—	—	—	—	—	2	—	—	—	—	—	2
Miocidaris sp. γ	—	—	—	—	—	—	—	1	—	—	—	—	1
Miocidaris ?, *sp. δ*	1	—	—	—	—	—	—	—	—	—	—	—	1
Anaulocidaris testudo	—	—	—	—	—	—	7	3	—	—	—	—	10
Plegiocidaris ?, *sp.*	1	—	—	—	—	—	—	—	—	—	—	—	1
Eodiadema ?, *sp.*	1	—	—	—	—	—	—	—	—	—	-	—	1
Mesodiadema margaritatum	—	—		—	—	—	1	1	—	—	—	—	2
Mesodiadema latum	? 1	—	—	—	—	—	9	2	10	1	—	—	23
Diademopsis incipiens	—	-	—	—	—	—	—	1	—	-	—	—	1
Diadematoid ambulacrum α	—	—	—	—	1	—		—	—	—	—	—	1
Diadematoid ambulacrum β	—	1	—	—	—	-	—	—	—	—	-	—	1
Diadematoid ambulacrum γ	—	—	—	—	—	—	1	—	—	—	—	—	1
Jaws	2	—	—	—	—	2	5	5	—	—	—	—	14
Number of Species and Varieties, about 20	33	3	—	—	1	5	35	15	10	3	—	—	105

ECHINOIDEA RADIOLES	CASSIAN						RAIBLIAN							
	Cserhát, Leitnerhof	Veszprém, Section VI	Veszprém, Csősz-Domb	Veszprém, Takarékpénztár	Veszprém, Section XI	Giricses-domb	Jeruzsálemhegy	Veszprém-Jutas Ry., Cutting I	Veszprém-Jutas, Quarry near Cutting I	Veszprém-Jutas Ry., Cutting IV	Veszprém, Lánczi	Veszprém, Köképalja, Section VII	Veszprém, Alsó-Erdő	Total Number of Specimens
Anaulocidaris testudo	—	—	—	—	—	—	238	219	3	13	—	—	—	473
Cidaris alata typica	2	—	—	—		—	—	—	—	—	—	—	—	2
Cidaris alata subalata	3	—	—	—	2	—	—	—	—	—	—	—	—	5
Cidaris alata poculiformis	—	—	—	—	—	—	33	9	—	—	—	—	—	42
Cidaris dorsata typica	3	2	—	1		1	—	—	—	—	—	—	—	7
Cidaris dorsata marginata	—	—	—	—	—	—	33	3	—	—	—	—	—	36
Cidaris scrobiculata	—	1	—	—	—	—	—	—	—	—	—	—	—	1
Cidaris fustis	—	1	—	—	—	·	4	—	—	—	—	—	—	5
Cidaris decorata	3?	1	—	—	—	—	1	—	—	—	—	—	—	5
Cidaris fasciculata	3?	—	—	—	—	—	—	·	—	1	—	—	—	4
Cidaris similis	2	5	—	—	—	—	—	—	—	—	—	—	—	7
Cidaris Waechteri	3	3	—	—	—	—	—	—	—	—	—	—	—	6
Cidaris Wissmanni	40	2	—	—	—	4	—	—	—	—	—	—	—	46
Cidaris Wissmanni rudis	155	10	—	—	2	4	—	—	—	—	—	—	—	171
Cidaris Wissmanni ovoid	—	7	—	—	—	—	—	—	—	—	—	—	—	7
Cidaris Hausmanni	1	—	—	—	—	—	—	—	—	—	—	—	—	1
Cidaris cf. *dorsata* et *Hausmanni*	6	—	—	—	—	1	—	—	—	—	—	—	—	7
Cidaris parastadifera	—	—	—	—	—	—	43	18	129	648	—	—	—	838
Cidaris decoratissima	—	—	—	—	—	—	7	—	—	—	—	—	1	8
Radiolus raiblianus	—	—	—	—	—	—	25	—	—	—	—	—	—	25
Radiolus penna	—	2?	—	—	—	—	5	—	—	—	—	—	—	7
Cidaris trigona	—	2	—	—	—	—	—	—	—	—	—	—	—	2
Radiolus lineola major		—	—	—	—	—	24	16	—	—	—	—	—	40
Radiolus lineola minor	44	—	—	—	—	—	32	14	49	1	—	—	—	140
Cidaris Meyeri	—	1	—	—	—	—	—	—	—	—	—	—	—	1
Number of Species and Varieties, about 25	265	37	—	1	4	10	445	279	181	663	—	—	1	1886

SUMMARY	MUSCHELKALK				CASSIAN						RAIBLIAN							
	Felsőörs	Vászoly, Ágasmagas	Tamáshegy	Alsódörgicse, Hangyas-Erdő	Cserhát, Leitnerhof	Veszprém, Section VI	Veszprém, Csősz-Domb	Veszprém, Takarékpénztár	Veszprém, Section XI	Giricses-domb	Jeruzsálemhegy	Veszprém-Jutas Ry., Cutting I	Veszprém-Jutas, Quarry near Cutting I	Veszprém-Jutas Ry., Cutting IV	Veszprém, Lánczi	Veszprém, Kőképalja, Section VII	Veszprém, Alsó-Erdő	Total Number of Specimens
Crinoidea	1	1	3	1	586	7868	4	—	—	35	62	23	418	8	1	1	—	9012
Echinoidea, tests . .	—	—	—	—	33	3	—	—	1	5	35	15	10	3	-	—	—	105
Echinoidea, radioles .	—	—	—	—	265	37	—	1	4	10	455	279	181	663	—	—	1	1886
Asteroidea	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
Grand Total	1	1	3	1	884	7909	4	1	5	50	542	317	609	674	1	1	1	
				6						8853							2145	**11,004**

The total 11,004 does not include a large number of quite indeterminable specimens and fragments from several of the Cassian and Raiblian localities.

SUMMARY AND CONCLUSIONS.

1. Stratigraphical and Faunistic.

From the preceding Table (pp. 237—240) the following facts may readily be gathered: the number of different forms found; the number of specimens of each form; the localities at which those specimens were found; the number of each species, and eventually the total number of specimens, from each locality.

A few notes may render the names of the localities more intelligible to the English reader. The Muschelkalk localities are all in Zala megye (Zala county). Felső means 'upper'; Alsó, 'lower'; hegy is a hill; domb, a butte; Erdő, a wood; Takarékpénztár, the Savings Bank; pados mészkő, bedded limestone; Lánczi is the name of an estate.

The various beds at each locality, denoted in the text by such signs as b *2*, e *4*, are not differentiated in the table, since their stratigraphical value has not proved to be great. For the present it does not seem possible to assign the rocks more precisely than to Muschelkalk or Conchylian, Cassian, and Raiblian. The localities are therefore associated according to those ages. The order of the species, on the other hand, is essentially zoological and systematic, for, when the work was begun, the information at my disposal as to the relative horizons of the fossiliferous beds was incomplete and uncertain, so that no attempt was made to deal with the specimens in stratigraphical order or according to locality.

By the time the Crinoid remains had been worked through it was recognised that, apart from the four localities whence six Muschelkalk fossils were obtained, the ten other localities could be divided into two sets, each yielding a common assemblage of species. One of these, which we may call the Cserhát group, comprised Cserhát (Leitnerhof), Section VI. at Veszprém, Csősz-domb, and Giricses-domb. The other, which may be called the Jeruzsálemhegy group, comprised Jeruzsálemhegy, Cutting I on the Veszprém-Jutas Railway, a quarry near Cutting I, Cutting IV, an opening on the Lánczi estate at Veszprém, and Section VII at Köképalja. Except for four doubtful specimens, the crinoid fossils found in the Cserhát group are quite distinct from those in the Jeruzsálemhegy group.

In attempting to decide on the comparative age of these groups, or on their age relative to one another, the Crinoid evidence at first appeared unsatisfactory owing to the paucity of specimens belonging to known species. It was, however, noted that the specimens of *Encrinus,* as well as the doubtful *Entrochi,* were confined to the Cserhát group, and, on general evolutionary grounds, this suggested that the Cserhát group was the older. The columnals of *Encrinus* are not very easy to distinguish, but the reference of a dozen to *Encrinus cassianus* and of another to *E. granulosus* seemed safe enough to warrant the inference that the Cserhát group was probably of Cassian age. The only species that could be recognised in the Jeruzsálemhegy group was *Isocrinus tyrolensis,* but this occurred in forms rather different from the normal St. Cassian columnals, and it seemed likely that they represented a time-mutation with its own local varieties. This, however, was enough to show that the Jeruzsálemhegy group, though younger than the Cserhát group, was not very much younger; and thus one came to the provisional conclusion that the Cserhát group was of Cassian age, and the Jeruzsálemhegy group of Raiblian age.

A general survey of the Echinoid fossils, made before their ultimate minute description was undertaken, confirmed this conclusion. Among the fragments of test, for instance, those of more pronouncedly Diademoid aspect were characteristic of the Jeruzsálemhegy group. The radioles of the Cserhát group included many that were indistinguishable from common Cassian species, whereas the radioles of the Jeruzsálemhegy group always seemed to be just a little different from Cassian forms.

On communicating these conclusions to Professor DE LÓCZY, I was delighted to find that they fully agreed with the results derived from the more extended palaeontological work already accomplished on other groups, and confirmed by such stratigraphical evidence as was available. This was subsequently well summarised by Dr. G. VON ARTHABER in «Lethea Geognostica» (ii Theil, I Bd, 3 Lief., pp. 424—429; 20 Dec., 1905). Such value as my conclusions may have is certainly enhanced by the fact that they were come to without any prejudice from external sources. Conversely their agreement with all other evidence is a further proof (if proof be needed) of the fundamental correctness of those principles that govern modern palaeontology.

Having furnished my quota of evidence, I leave to the Editor of the series. Professor L. DE LÓCZY, all discussion concerning the geological relationships of the various localities. We may, however, consider more closely the relations of the Cserhát and Jeruzsálemhegy Echinoderm faunas to those found in adjacent regions, and to one another.

The Crinoid fauna of the Cserhát group comprises at most eight recognisable species; three of these belong to *Encrinus,* and three to *Isocrinus;* the generic position of the others, as well as of various less well-marked columnals, is doubtful, but it is probable that *Dadocrinus* is represented. If, for reasons previously given, we regard this fauna as of Cassian age, the most remarkable feature is the small proportion of species common to St. Cassian and Bakony: only *Encrinus cassianus,* one doubtful fragment of *E. granulosus,* and a few ossicles allied to «*Pentacrinus venustus*». Even the columnals referred to *E. cassianus* are far from normal, being dwarfed forms. Moreover these very species are just those that are least characteristic of the Cassian horizon; at least, both *E. cassianus* and *E. granulosus* have been recorded from both lower and higher horizons.[1] The determinations, however

[1] In addition to references already given, see: C. F. PARONA, 1889, p. 148, *E. cassianus* columnals in Raiblian of Acquate, Lombardy; WÖHRMANN & KOKEN 1892, p. 170, *E. cassianus* columnals in Raiblian dolomite of the Schlern plateau; F. BROILI, 1904, pp. 150, 151, and F. BLASCHKE, 1905, p. 166, *E. granulosus* and *E. cassianus* from Pachycardientuffe; A. MARTELLI, 1905, pp. 330, 331, *E. granulosus* and *E. cassianus* in Wengen Beds of Montenegro; P. PRINCIPI, 1908, p. 201, *E. granulosus* columnals from Rhaetic [!] of Mte. Malbe near Perugia

have proved to be inexact in some cases, and may be so in all. The characteristic *Encrinus* of Cserhát, *E cancellistriatus*, is a new species, unknown out of Bakony. Can it possibly be the same as certain columnals from the "Mergellage aus dem Scharizkehlthale bei Berchtesgaden", probably of Cassian age, which Gümbel (1861, p. 220) called "*Encrinus radiatus* v. Schaur., var. *verrucosus*", and said they were "dadurch ausgezeichnet, dass die Oberfläche fein gekörnelt ist"? I make the suggestion on the supposition that by "Oberfläche" Gümbel meant the joint-face, and that his specimens belonged to *Encrinus*, though not to *E. radiatus* Schaur., which, as stated on p. 16, is a *Balanocrinus.*

Comparison of the Pentacrinidae shows even more remarkable dissimilarity between the Cassian and Cserhát faunas. Of three species of *Isocrinus* and two of *Balanocrinus* found at St. Cassian, not one occurs in the Cserhát group, while the three species of *Isocrinus* characteristic of that group, *I. candelabrum*, *I. scipio,* and the abundant *I. sceptrum,* are unknown elsewhere. *Isocrinus propinquus* has been recorded from so many localities, that its absence from Bakony may seem surprising; but the records, where I have been able to check them, have proved incorrect (see pp. 31, 54). The really interesting point is that, although descendants of *Isocrinus tyrolensis* and *I. propinquus* (the latter in the form of *I. Hercuniae*) are found in the Jeruzsálemhegy group, still neither of these species is represented (unless by one or two very doubtful fragments) in the Cserhát group.

The inference I have drawn is that the Cassian Pentacrinids did not find their way into Bakony till Raiblian times, and thus arose this excellent example of homotaxis, the Cassian species of St. Cassian being more like the Raiblian species of Bakony than like their actual contemporaries.

Besides *Isocrinus Hercuniae, I. tyrolensis major* with its varieties, and a single doubtful columnal of *I. candelabrum,* the Jeruzsálemhegy group contains no other Crinoids. The Encrinidae, which so short a time before were numerous in species, and so rich in individuals as to build up masses of rock from their remains, are now not represented by a single columnal.

From the Pachycardientuffe of the Seiser Alp, Broili (1904) has recorded *E. cassianus*, *E. granulosus,* and *E. varians.* From the Cardita Oolith of the N. Tyrol and Bavarian Alps, Wöhrmann (1889) has recorded *Traumatocrinus caudex* and a species already discussed under *Encrinus granulosus.* These are the stragglers of the great host of Triassic Encrinidae, the last of their race. In the Jeruzsálemhegy group not one of them is found. The conditions that permitted the migration of Pentacrinids from the Tyrol into Bakony were, apparently, not so favourable to Encrinids. The various species of *Encrinus* were, so far as we know, firmly rooted to the sea-floor by a spreading base; the Pentacrinidae, on the other hand, attach themselves by their cirri, and, either loosing their hold or breaking across the stem at a syzygy, may move during adult life to another spot. They have further advantages over the Encrinidae in the greater development of their subvective system by the repeated branching of the arms, and in their capacity for reaching higher and therefore richer sources of food through their longer and more highly developed stems. We cannot follow all the variations of current and food-supply in these Triassic seas; but we have reason to believe that the food-supply was in places or at times diminished, for we see the result of it in stunted faunas. When such unfavourable conditions supervened, it is easy to understand why the Pentacrinidae survived though the Encrinidae perished. No obscure or metaphysical reasons are required; but it is of interest to note that with the passing of the Encrinidae we bid farewell to what may be regarded as the last representatives of the Palaeozoic types of Crinoid, the direct descendants of Carboniferous genera.

Turning to the fragments of Echinoid Test, we find in the Cserhát group only one determinable species, but of that there are 27 specimens. This is regarded as a new species, *Triadocidaris persimilis;* but its close relationship to the St. Cassian *T. subsimilis* is pointed out on p. 75. The remaining fragments of test are both few and obscure, but appear to represent about six other species. The total number of test-fragments (including jaws) from the Cserhát group is 42.

The Jeruzsálemhegy group has yielded 63 test-fragments; and these represent at least eight clearly distinct and recognisable species. Probably there are remains of 10 or 11 species, as opposed to the 7 from Cserhát. Of these species three, with a doubtful fourth, are referred to *Triadocidaris;* two, and a doubtful third, to *Miocidaris;* one to *Anaulocidaris;* two to *Mesodiadema;* and one to *Diademopsis.* The species of *Triadocidaris* and *Miocidaris* suggest a connection with the St. Cassian fauna, but none of them agrees with described Cassian species; on the contrary they indicate a higher horizon. *Triadocidaris praeternobilis* and *T. immunita* approach the Diademoid type of ornament; the species of *Miocidaris,* in their wide interambulacrals with contiguous or confluent scrobicules, seem to have passed beyond the evolutionary stage of the Cassian species. It is, however, the presence of *Mesodiadema* and a probable, though primitive, *Diademopsis* that definitely marks the horizon as supra-Cassian; and the actual reference of it to Raiblian is confirmed by the unexpected identification of our *Mesodiadema latum* (p. 118) with the interambulacrals provisionally referred by Wöhrmann to his *Cidaris Schwageri* (p. 229)

The distinction that study of the crinoids and of the echinoid tests enables one to draw between the Cserhát and Jeruzsálemhegy groups is fully confirmed by the Echinoid Radioles. The evidence is strong enough, but there are reasons for doubting whether it is quite so strong as inspection of the Table would lead one to suppose. According to that Table, the radioles fall into about a score of species, of which only four are new. Of these species, 7 are confined to the Cserhát group, and 4 to the Jeruzsálemhegy group. In three of the others there is a special form characteristic of the Jeruzsálemhegy group. The remainder are few in specimens and several of these are doubtful. This evidence then is conclusive as to the distinctness of the faunas; it appears to be no less conclusive as to their age. Seeing that nearly all the Cserhát radioles are assigned to well-known Cassian species, while in the Jeruzsálemhegy group are such species as *Anaulocidaris testudo* and *Cidaris parastadifera,* less familiar but still known from Raiblian localities elsewhere, the conclusion seems so inevitable that all the previous laboured argument looks unnecessary if not absurd. But I think any one with a wide knowledge of Echinoids would have criticised me had I based an argument as to age on radioles alone. Although the Cserhát radioles are referred to Cassian species, it must be remembered that the same is not the case with the Cserhát fragments of tests. It is therefore quite possible that the radioles do not really belong to the same species as do their isomorphs at St. Cassian: the tests may be different, and yet the radioles indistinguishable. Although by the necessities of the case, we have as a rule to speak of radioles and test-fragments by different names, still we have no right to assume that those found in the same rock represent different species; therefore we ought not to base on the radioles any conclusions more weighty than those supported by the test-fragments.

If ever the general principles just laid down may be set aside, it is either when a sufficiently large number of radioles enables one to study the whole range of variation (as in the case of *Anaulocidaris testudo*), or when the material is well enough preserved to permit detailed examination and comparison of the microstructure. The two methods ought, no doubt, to go hand in hand, but this is rarely possible with the Bakony material. Readers of the descriptions will, however, have observed that every pains has been taken to apply these modern methods in arriving at the determinations. Fortunately also I have been able to study some of the rare specimens already described from other Raiblian localities, and to show a correspondence even closer than might have been inferred from the previously published names.

It cannot too often be repeated that arguments based only on previous lists and records are rarely satisfactory. With the more minute subdivision of the strata, more precise description and determination of the fossils are required, and identifications that passed well enough at an earlier stage of the science have constantly to be subjected to fresh scrutiny. It is for this reason that it has been necessary to include in the present memoir so much discussion of species not found in Bakony at all, and for the matter of that not found in a good many other places where they have been said to exist. *Isocrinus propinquus* and *Anaulocidaris Buchi* are notable instances. On the other hand I have refrained from the discussion of some records (e. g. Pichler, 1857, 1866), when I have not examined the specimens on which they were based. This explains the patent omission of reference to isolated radioles of *Cidaris alata, C. Roemeri,* and *C.* cf. *dorsata,* recorded from the Raiblian of the Schlern plateau by Wöhrmann & Koken (1892, p. 171). The first and last of these may, for all one can tell, belong to the Raiblian mutations *poculiformis* and *marginata,* while the supposed *C. Roemeri* might prove to be *C. parastadifera.*

The names of species from the Trias of Kotel in Bulgaria, published in a preliminary note by Mr. P. Bakalow (1905) sound interesting; but of course one can say nothing till the descriptions are published. His *nomen nudum, Cidaris poculiformis,* calls to mind the circumapical radioles of our *Cidaris alata poculiformis* and *C. dorsata marginata,* and suggests that the age of the deposit may be Raiblian. His citation of *Entrochus insignis* Toula shows that these peculiar columnals, so reminiscent of the Cretaceous Pentacrinid *Austinocrinus* are really Triassic, and not of that Cenomanian age to which they were assigned by Toula (1890, p. 347, Taf. vi, ff. 3—6). Specimens from the type-locality, kindly sent me by Mr. Bakalow (Brit. Mus. E 14076), suggest that the species is a passage-form between *Encrinus* and either *Isocrinus* or *Millericrinus.* There is nothing like it from Bakony. Of previously described Triassic forms that which most nearly approaches it is the much smaller *Encrinus radiatus* Schaur. The other columnals figured by Toula (1890, Taf. vi, ff. 7—10) probably comprise the forms that Bakalow cites as *Encrinus granulosus, Pentacrinus Fuchsii,* and *P. laevigatus.*

A special case is presented by the fauna of the Pachycardientuffe of the Seiser Alp. Its Echinoderm components were all referred by Dr. Broili to Cassian species; but more minute comparison seems to show that these identifications, though not absolutely wrong, require some qualification. The general difference of facies, which was not unnoticed by Dr. Broili, seems to be due less to local conditions (whether of environment or preservation) than to a slight mutation in the direction of Raiblian species. I use the word 'mutation', in its original palaeontological sense, to describe this change, because I regard it as correlated with a lapse of time. That is to say, I am led to regard the Pachycardientuffe as between the true Cassian and the undoubted Raiblian. Since I came to this conclusion Professor Koken has discussed the age of the Pachycardientuffe very fully and places them in the Raiblian (N. Jahrb. Mineral, 1906, II, pp 12—19). So long as this is understood to mean Lower Raiblian, no objection need be raised on the score of the Echinoderms.

The following are the more important references to the Echinoderms of the Pachycardientuffe in the present memoir. The so-called *Pentacrinus propinquus*, p. 54; *Anaulocidaris Buchi,* mut. nov *granulata,* p. 168; *Cidaris scrobiculata,* a slight mutation, p 183; *C. decorata,* p. 186; *C. similis* ?, pp. 190, 192; *C. Hausmanni* mut. nov. *tofacea,* p. 205; *C. trigona,* p. 223.

In the paper just referred to, Professor Koken speaks of certain «*Cidaris*-Stacheln und *Encrinus*-Glieder» as «ganz indifferente» (p. 17). This is a reproach that should be removed by more careful collecting in the field and more minute study in the museum.

2. Morphological.

Whether for morphological or for systematic description, one of the first necessities is a precise and adequate Terminology. Two causes have led me to discuss the terminology of various well-known structures at greater length than might have been anticipated in a work of this nature. First, the existing want of harmony between different writers, as regards both multiplicity of terms and differing applications of the same term. Secondly, the more detailed and minute description, necessitated by the fragmentary nature of the materials, involved an extension of the existing terminology in the interests of both precision and brevity.

The structures for which a revised terminology has therefore been proposed are: 1. the Pentacrinine Stem (pp. 24—30); 2. the Test of the Regular Echinoids, particularly as regards its ornament (pp. 59—65); 3. the Jaw-apparatus of the Regular Echinoids (pp. 129—130); 4. the primary Radioles (pp. 135—136).

Turning now to questions of Anatomy, it will be recognised that no startling discoveries can be expected in material of this nature. There are, however, a few points of general interest.

Among the Crinoids, the most striking discovery to my mind is that of the axial nerves in the stem of *Isocrinus candelabrum* (p. 41). Now that they have once been noticed, it is probable that traces of these delicate structures will be found in other fossil crinoids, and that they will help us to unravel the relationships between Monocyclic and Dicyclic crinoids.

In the Pentacrininae with their highly specialised stem, the occurence of truly hexagonal columnals is so rare, that the discovery of a hexagonal fragment in *Isocrinus Hercuniae* is worthy of note (p. 49, Pl. IV, figs. 106, 107).

The stem of the same species presents syzygies of an interesting character, in the development of a special system of fine crenellae, which overlie or supersede the normal crenellae of the joint-face (p. 52). As a rule the syzygial modification consists merely in a flattening out and disappearance of the normal crenellae; but here is an entirely fresh structure arising. These fine crenellae may be compared with the radiating striae that characterise the brachial syzygies of so many of the later crinoids. Since there can be no doubt as to the morphological individuality and independence of the two components of a columnal syzygy, this may be regarded as an additional argument for the independence of the two elements in a brachial syzygy. I could never see why the brachial syzygy should be regarded as having arisen in a different way from the syzygy in the stem, since the two kinds have a similar structure and a similar function. But this is not the place for detailed discussion of that controverted question.

The patina or dorsal cup of an *Isocrinus* (probably *I. scipio*), described on p 56, owes its chief interest to the fact that it is the only one known from the Trias. Though already crypto-dicyclic, it presents features reminiscent of the earlier Pentacrinidae and their probable ancestors in the Carboniferous rocks.

The brachial, probably of an *Isocrinus,* found in the same Cserhát beds, is also primitive in various features (p. 58).

Towards the anatomy of the Echinoids, the chief contribution is the more exact description of the flexible union along the junction of the ambulacrum with the interambulacrum, first described by Doederlein. This is here described in species of both *Triadocidaris* and *Miocidaris* (pp. 69, 73, 81, 85), and is also shown to occur in early Diademoids. The main correction is the proof that the denticles of the interambulacrals slide in the grooves between the ambulacrals, and not in the grooves on the ambulacrals. Thus the denticles on the inner bevelled face of the interambulacrals correspond to the projections on the vertical edges of the same plates in later Cidarids, and there is no break in the evolution. The gradual nature of the evolution is further proved by the observation that the angle of the bevel becomes steeper as the oral end of the suture is approached; in fact the suture is nearly if not quite vertical at the level of the perignathic girdle. This latter structure is here seen in its early development, and it is a fairly obvious inference that the mechanical advantage conferred by greater rigidity in this region led to the perpetuation of those forms in which the suture was here more vertical; and that the change in the nature of the suture gradually extended from here to the adapical regions of the test.

The flexibility so obvious in the adradial suture is regarded as a relic of the Streptosomatous condition characteristic of the whole test in so many Palaeozoic Echinoids. Other relics of the same condition are found in the sutures between the interambulacrals themselves, both in *Miocidaris* (p. 86) and in *Mesodiadema* (p. 122).

Our knowledge of particular genera is advanced most in the case of *Anaulocidaris,* which the abundant Bakony material has enabled me to reconstruct in great part, and to resuscitate as an independent genus of Cidaridae. Not only have we here a complete series of radioles (p. 138), but it is believed that the new species, *A. testudo,* is also represented by several interambulacral plates (p. 94).

The useful work of Hesse (1900) on the micro-structure of Echinoid radioles showed that much might be learned by applying this method of research. The Bakony material is not always well adapted for the preparation of thin sections, but those sections that have been successful have proved most instructive. Not only have they afforded novel criteria for the determination of species, of special value in those cases where the outer forms are merged in apparently inextricable confusion, but they have manifested many curious structures. HESSE had already shown that the radioles from the Cassian beds were rather aberrant from the normal Cidarid type, and this is fully confirmed by the more elaborate studies here published. Some of the radioles of course do not really belong to the Cidaridae; but even in those cases where the name «Cidaris» seems less inappropriate, such as *C. Hausmanni*, *C. parastadifera*, and *C. trigona*, the structures revealed are highly specialised and peculiar. For adequate discussion of them the reader must be referred to the individual descriptions and plates (pp. 150, 173, 186, 189, 193, 197, 200, 203, 211, 214, 218, 222, 231, 233; pls. XIV—XVIII). The nature of the material rendered the preparation of microphotographs out of the question in many cases, so that all these complicated structures have been reproduced as pencil drawings. This of course is a lengthy process, but the utmost pains have been taken by Mr. G. T. GWILLIAM, and I have myself repeatedly checked his drawings with all possible care.

We may now enquire what light the facts contained in this memoir shed on the Evolution of the groups concerned. Fossil invertebrates of Triassic age have always this peculiar interest, that they come between the Palaeozoic and Mesozoic forms of life, which have in so many groups of animals seemed to be constructed upon distinct plans. The former generation of palaeontologists, to whom the intervening Triassic fossils were not so well known, were so struck by the differences that they were accustomed to place the Palaeozoic and the later genera in distinct Orders; thus, among Echinoderma were established the Palaeocrinoidea and Neocrinoidea, and the Palechinoidea and Euechinoidea. So soon as the conception of one continuous process of evolution became part of the everyday thought of working palaeontologists, the fundamental error that underlay these conceptions was perceived. In the first paper that I wrote on Crinoidea (Feb. 1889, Quart. J. Geol. Soc. XLV, p. 617) I took the opportunity of criticising the classification then current, and had the pleasure of seeing it abandoned shortly afterwards by those who had themselves done so much to found and elaborate it — Messrs. WACHSMUTH & SPRINGER and P. HERBERT CARPENTER. The division into Palechinoidea and Euechinoidea has had a longer life, for it was still used by K. VON ZITTEL in the second edition of his «Grundzüge der Paläontologie» (1903, pp. 203, 206); but it had already been definitely discarded by my colleague Dr. J. W. GREGORY in the chapters that he wrote for my volume on «The Echinoderma» in LANKESTER'S «Treatise on Zoology» (1900). In breaking down these divisions, the Triassic Echinoderms have played an important part, but, since these broader questions may be safely regarded as already settled, the bearing that this memoir has on them needs only slight mention.

The Encrinidae are in themselves a natural bridge; for the Family, at least as I have defined it (op. cit. 1900, p. 181), includes the Carboniferous genera *Stemmatocrinus* and *Erisocrinus*, and the Triassic *Encrinus*. Details of classification may be open to criticism, but there can hardly be any hesitation in placing *Encrinus* among those Dendrocrinoidea that have pinnulate arms, usually bifurcating into two definite rami. In *Encrinus* itself the arms are so specialised in this particular direction that the genus cannot serve as starting-point for the later genera of Dendrocrinoidea with their more extended and usually more branched arms. In these later genera moreover the patina is reduced in size, while the thecal cavity is enlarged, or at least maintained, by the upward extension of the flexible tegmen in such a way as to incorporate the proximal brachials in the cup. Such genera therefore fall into the Grade Articulata. The earlier forms of this plan of structure are represented in the Trias by *Dadocrinus* and *Holocrinus,* and there is some evidence from columnals that both these genera occurred in Bakony. Their fragmentary remains unfortunately throw no light on the origin of those two genera, and I can only repeat my suggestion (1900) that they were descended from Carboniferous Dendrocrinoidea in an earlier stage of arm-specialisation than that reached by *Encrinus.*

The columnals found in Bakony do, however, comprise some forms of interest to the student of evolution. The tendency of *Encrinus* columnals to assume a quinquelobate pattern is well known, and such specimens are noted on pages 11, 12, 15, and 16. This pattern, however, rarely is so far developed as to suggest that the ligament-fibres of the stem were grouped in five as they are in the Pentacrininae. *Entrochus insignis* is more advanced in this direction, but may not have belonged to a true *Encrinus.*

The small columnals from the Cassian beds of Cserhát, introduced as *Entrochus quinqueradiatus* (p. 19), have a distinct pentamerous symmetry, but it is doubtful whether any of the markings can be described as petaloid areas. In *Holocrinus* (p. 21), though of earlier date, portions of the stem had certainly attained this stage, and the crenellae were grouped round the five narrow areas.

The columnals provisionally described as «*Pentacrinus venustus*» elucidate the origin of the Pentacrinine stem from the Entrochus plan. One factor in the evolution appears to have been the development of stem-cirri. In the earlier crinoids cirri are generally confined to the root end of the stem, where they are somewhat irregular. In some stems of Carboniferous age, cirri occur at higher levels; but they are not in verticils, are unaccompanied by any obvious modification of the columnar joint-faces, and have no definite orientation. In these forms the stem-lumen is relatively wide, and the nerves that pass from it to the cirri are therefore not restricted in direction. As the stem and its lumen become narrower, the axial nerves of the stem have less freedom of movement, and the branches arising from them tend to be strictly radial or interradial in position according to the radial or interradial orientation of the axial cords. Thus the cirri also become definitely oriented. This orientation becomes still more precise as the cirri fall into verticils, a structure that arises with the gradual development of syzygies and of the functions that they connote. This restriction of the lateral nerves to definite meridians must obviously have its effect on the stroma of the stem, and must tend, at all events in the neighbourhood of the verticils, to throw the ligament-fibres into groups between the nerve-meridians. In this «*Pentacrinus venustus*», then, we see the crenellae retaining their primitive length immediately above the cirri, but in the intervening spaces they are shortened; and we may infer that this shortening is due to the concentration of the ligament-bundles. This structure is still far removed from that of the Pentacrininae, since in place of the radial ridge-group, there is here only a single radial ridge.

Among the *Isocrini*, the joint-faces in *I. candelabrum* appear to be the most primitive. The petal-floors are still small and unstable, and the relatively long crenellae as they near the periphery curve upwards so as to be more nearly parallel to the perradius, as they are in «*Pentacrinus venustus*». Between these two forms there was, we must suppose, a stage in which the crenellae or ridges, instead of remaining parallel to the perradius, tended to fan out more from the petal-floor. Thus the first stage in the formation of a radial ridge-group would have been the loss or alteration of the single radial ridge, and its replacement by two ridges meeting in an angle on the perradius at the periphery. In the next stage two pairs of ridges would meet in an angle on the perradius, thus forming an incipient radial ridge-group; and this stage is actually found in the smaller columnals of *I. candelabrum* (pp. 38, 41).

Isocrinus scipio (p. 43) also has very few radial ridge-groups, and it is quite possible that the single short radial ridge often found in this species is the remains of the long radial ridge in «*Pentacrinus venustus*» rather than a secondary modification of the adcentral pair of ridges.

It is easy to see how these primitive stages progressed towards the more developed stage with a number of pairs in the radial ridge-group, and the history need not here be followed further.

No sooner was the Pentacrinine type of columnal established, than it began to diverge in three directions, characteristic of the three genera *Isocrinus*, *Pentacrinus*, and *Balanocrinus*. Such a form as *Isocrinus Hercuniae* (p. 48) is of much interest because it combines in a partly developed condition characters of all three genera. When the radial ridge-groups are composed of a series of ridges at right angles to the perradius, it would only need the suppression of the radial triangle and the shortening and equalisation of the peripheral crenellae to produce a joint-face like that of *Balanocrinus*. On the other hand, the increase of the radial triangle, with the elongation of the petal-floors, would produce the plan of *Pentacrinus*, as it appeared shortly afterwards in *P. versistellatus* Schafh.

Among the Echinoidea, the chief evolutionary problem that confronts us is the origin of the Diademoida, with which is probably bound up the origin of the whole Sub-class Regularia Ectobranchiata, if not the origin also of all the Irregularia.

So far as any negative can be firmly established in palaeontology, it appears certain that none of the Ectobranchiata or of the Irregularia existed before Triassic times. They must therefore have had some Triassic or Pre-Triassic ancestors. Apart from the doubtful *Tiarechinus*, all Triassic Echinoids that are not Diademoids are Cidaroids, and in fact belong to the one family Cidaridae. The other Orders of Palaeozoic Echinoidea scarcely need consideration. The peculiar Ordovician and Silurian genera *Bothriocidaris*, *Palaeodiscus*, and *Echinocystis* may have had descendants, but were certainly not the immediate ancestors of any Triassic genera. The gradual specialisation of the ambulacral plates in the Melonitoida prevents us from considering that Order as ancestral to forms with far simpler ambulacrals.

That the Cidarid type had been evolved by Permian times, we know from the presence of *Miocidaris Keyserlingi* in the Magnesian Limestone. In Carboniferous rocks the nearest approach to the Cidaridae is presented by the Archaeocidaridae (or Lepidocidaridae), and there is no reason to doubt that *Archaeocidaris* (= *Echinocrinus*) is a true ancestor of *Miocidaris*. It has been fully shown to how great an extent the flexible union of the plates characteristic of the Archaeocidaridae is preserved in many of the Permian and Triassic Cidarids. The only point on which further evidence is needed is the transition from the multiserial to the biserial interambulacrum. Perhaps the apparently peculiar form from the Permian of the Saltrange, *Cidaris forbesiana* DE KON, will ultimately elucidate this.

Of the Order Diademoida, the first representatives appear, somewhat doubtfully, in the Cassian beds, and more certainly in the Raiblian beds. All, so far as they are capable of exact determination, belong to the Family Diadematidae, and apparently to the genera *Mesodiadema* and *Diademopsis* (see pp. 102—128), though one plate from the Cassian of Cserhát is doubtfully referred to the Acrosaleniid *Eodiadema*, a genus in which LAMBERT has also placed *Cidaris regularis* MÜNST. (p. 101).

The evidence available points to the derivation of these forms from the Cidaroida, and probably from the Cidaridae (see p. 116). As to their origin from Cidaroida there are no reasonable grounds for hesitation. In many features the Diademoida agree with the Cidaroida, the main differences being these: The Diademoida possess external branchiae, sphaeridia, ophicephalous and trifoliate pedicellariae, and a lumen in the primary radioles. We do not know whether the earlier Diademoida had sphaeridia or pedicellariae like the later ones; but since these structures must have been evolved gradually, the precise date of their appearance is of no great importance. They may have arisen concomitantly with the branchiae, or they may have been developed subsequently. The detailed description of numerous radioles in the preceding pages has shown clearly that the lumen arose gradually by the breaking down and resorption of the axial complex; it has also shown that the regular arrangement of wedge-like septa had scarcely been reached by the most Diademoid of Triassic radioles (see especially p. 225).

A more important difference is the possession of external branchiae. These are paired interradial diverticula from the peripharyngeal sinus, which pass to the exterior at the margin of the peristome, just where the interambulacrum meets the adjacent ambulacrals. In dry tests or in fossils the presence of these branchiae is to be inferred from the presence of the buccal or branchial clefts, which notch the peristome at these points. In many early species, however, which all writers agree to refer to the Diademoida, these notches are very feebly developed, and it is quite obvious that the branchiae may have existed without the notches, and that the circle of the peristome may still have been as complete as in the young specimens of *Strongylocentrotus droebakensis* figured by LOVÉN (1892, «Echinologica» pl. iv). In the ontogeny of living forms, the notches arise by resorption of the interambulacrals, and are preceded by the branchiae. The same course was probably pursued in phylogeny. We cannot therefore expect any definite palaeontological evidence as to the origin of the external branchiae.

There are, however, other changes in structure that render the appearance of external branchiae about this time quite probable. The name «branchiae» implies that these organs are essentially respiratory. This may be the case, but they are not wholly so, and their inception may have been due to another cause than the need for fulfilling this function. Dr. J. von Uexküll (1896) has shown that their extrusion and retraction are effected by changes of pressure on the fluid in the peripharyngeal sinus, and that this pressure is normally produced in life by the contraction of the «ligamenta obliqua externa» Valentin, which pass from the forked ends of the compasses to the interradial regions of the perignathic girdle. Thus we need no longer say of these muscles with Lovén (1892, p. 43), «their function is not yet properly understood». On the other hand von Uexküll shows that the pressure is relieved by the contraction of the compass-muscles, that is to say the five broad muscles that join the sides of the compasses and form a pentagonal ring at the adapical end of the lantern; when this ring is raised up in a funnel-shape, the space of the peripharyngeal sinus is enlarged, and the fluid withdrawn from the external branchiae. The Cidaridae have compasses with their associated muscles, and are similarly subject to a change of volume in the peripharyngeal sinus. This is perhaps not so marked, since the limiting membrane appears to be less flexible; still some provision has to be made for the reception of superfluous fluid, and reservoirs are duly provided by the organs of Stewart, sometimes called «internal branchiae». It is, however, also the case that the internal pressure is partly taken up by the peristomial membrane, as may easily be proved by direct experiment. The greater the extent and flexibility of this membrane, the less would be the mechanical necessity for either external or internal reservoir-sacs. In the older Echinoids with a flexible test and less rigid perignathic girdle, the peristomial membrane and its surroundings must have yielded to the internal pressure far more than in the rigid forms of later origin. In the Silurian *Palaeodiscus*, where no trace of a perignathic girdle has yet been described, and where the differentiation of plates in the peristomial region is very slight, the peristomial limits of the peripharyngeal sinus are readily distinguished in the fossils, owing to the protrusion of the plates on the death of the animal in consequence of the greater pressure of the contained fluid. In this genus, and probably in all primitive Echinoids, the lantern was not so high as in later forms, and the cavity of the sinus must have been relatively smaller. Consequently changes of pressure would not have necessitated large reservoir-sacs; and it may be that none existed at all.

The facts that have been very briefly summarised in the preceding paragraph may perhaps permit some speculation as to the course of evolution. They suggest that, as the test became more rigid, especially in the circumoral region, as the lantern and its containing sinus increased in relative size, and as auricles and ridges were formed on the interambulacra for the attachment of the lantern-muscles, so there arose the need for reservoirs. These at first need not have been due to respiratory requirements, and in this regard it is suggestive to note von Uexküll's experimental proof that *Cidaris papillata* is far less subject to asphyxiation than the ectobranchiate genera which he investigated. These reservoir-sacs were, we know, developed in two different places: first, the organs of Stewart, passing up from the compass-sacs into the general body cavity; second, the external branchiae. The former, though called branchiae, cannot, one would think, subserve respiration to any great extent; but here further experiment is wanted. The latter, as soon as they reached any size, must have been far more effective in respiration than the organs of Stewart, owing to their contact with the external medium. It may be that the Permian and early Triassic Cidarids were still halting between these divergent paths of development. From their peristomial skeletal structures, those of the primitive Triassic Diademoids still present no great difference. The differences that so soon afterwards appeared may have been a consequence of these different responses to pressure. Since in the Cidaridae the relief of pressure took place internally, the coronal plates continued as heretofore to pass on to the peristomial membrane, and if the ambulacrals, as Lovén held, migrated downwards more rapidly, they would have been the less fitted to support internal processes. In the Ectobranchiate line of descent, on the other hand, the evagination of the peristomial membrane at the edges of the interambulacra checked the passage of interambulacrals entirely, and also affected the passage of the ambulacrals, which became in Lovén's phrase the «dissolved wrecks» of their former selves.

If this account be accepted as approximately correct, we may consider what effect such changes would have on the perignathic girdle. In the Cidaridae the large internal projections (auricles) for the attachment of the pyramid or maxillar muscles are confined to the interambulacrum; to each auricle is fixed a protractor muscle on its interradiad margin, and a retractor on its upper and radiad margins. In consequence of this proximity of their respective external attachments, there is a torsion of the muscle-fibres as the muscles bend round each other to reach their attachments on the maxillae; this is well shown in Lovén's figures (1892, «Echinologica», pl. vi, figs. 39—42). There is therefore a tendency for the auricles to diverge from the interradius over the ambulacra, and this is more marked in modern Cidarids than in the Triassic specimens here figured (Pl. VI, figs. 130, 142, 143, 147, 148). When the passage of the coronal plates on to the peristomial membrane became checked by the extrusion of branchial sacs, it became possible for the perignathic attachments of the retractors to assume a more mechanically advantageous position nearer the radii, since projections for their fixation could now more readily be formed upon the ambulacra (Lovén, 1892, figs. 47, 48). Lovén considers that the adradially placed auricles of the Ectobranchiata are in fact derived from the ambulacrals. This may well be the case, and yet our knowledge of the constant changes in the growing Echinoderm skeleton, due to resorption and redeposition, renders in no way improbable the suggestion that the auricles may have migrated from an interambulacral to an ambulacral position quite gradually. This appears to have been the opinion of M. Neumayr, (1889, «Stämme des Thierreiches» p. 370), who indeed spoke of this transition as the first stage in the development of the Glyphostomes. The *a priori* considerations already adduced suggest that it was really a consequence of other changes, and the facts of structure described in this memoir (especially p. 116) show that it actually was not the first step. In *Mesodiadema* and in *Diademopsis incipiens*, for instance, the internal processes were either still interambulacral or were reduced to an extended ridge; in *Diademopsis Bowerbanki* this ridge remains, while at its adradial ends slight processes have arisen on the ambulacrals. Confirmatory evidence is desirable, but the facts seem to indicate that there really was a gradual movement of the attachments of the retractor muscles from an interambulacral to an ambulacral position.

When once the ambulacrals had become concerned in building up the perignathic girdle, a further check was placed on their free passage into the peristomial membrane. Thus the view of Lovén, Neumayr, and Duncan that the peculiarities of the Diadematoid ambulacrum are due to pressure between the freshly formed plates at the apex and the restrained plates at the peristomial margin seems to contain much truth, though other causes need not be excluded.

Here for a moment we may pause to consider a possible alternative. It might be a less violent hypothesis to deduce the Ectobranchiata from another line of Cidaroida represented in Devonian and Carboniferous times by the Lepidocentridae. In this Family the interambulacral plates do not pass on to the peristomial membrane, so that one of the chief features differentiating the Diademoida from the Cidaridae is already present. But in the Lepidocentridae this absence of interambulacrals from the peristomial membrane appears to be due to a different cause. In this Family the initial single interradial plate is retained in the adult, whereas the Diademoida are clearly derived from forms in which the adoral interambulacrals have disappeared. A considerable series of genera would therefore be required to bridge the gap between the Lepidocentridae and the Diademoida, but of this postulated series no representatives are known. This hypothesis therefore would present more rather than fewer difficulties.

Returning to the hypothesis of the origin of the Diademoida from the Cidaridae, we find the state of affairs just the contrary. More than once in the preceding pages the difficulty mentioned has been that of deciding whether a certain fossil belonged to the Cidaridae or the Diadematidae. Were the complete test, and still more the living animal, preserved to us, the difficulty might not occur; but when we have only the corona or fragments of it to deal with, the impression gained is that there was a very gradual change in all its elements, and that the difficulty is merely an expression of this fact. Let us then proceed to discuss the change in the ambulacra.

The essential differences between the Cidaroid and Diademoid types of ambulacrum are these: In the Cidaroid the primary ambulacral plates are equal in size, equituberculate, distinct, in simple series, those of the *a* column alternating with those of the *b* column, with the pore-pairs also in simple series (unigeminal). In the Diademoid the primary plates are united by threes, in which the middle plate is the largest and bears the largest tubercle; the sutures are obscured, especially on the outer face where the base of the large tubercle encroaches on the adjacent ambulacrals; the pore-pairs of each triad form an arc, with the large tubercle as its approximate centre. In the ultimate development of this type, the triads of primary ambulacrals are so closely united as to form a single large plate or major; and it is these majors, and not the primaries, that alternate along the zigzag suture between the *a* and *b* columns. A slighter difference generally obtains in the disposition of the podial pores: in the Cidaridae it is usual for those of a single pair to be approximately equidistant from the adoral margin of the ambulacral, and to be unenclosed by a distinct raised rim or peripodium; in the Diademoida, as in many other Ectobranchiata, there is unsually a peripodium, and its long axis lies at an angle to the long axis of the ambulacral, so that the inner or radiad pore is the more adoral. Finally, the width of the ambulacra tends to be relatively greater in the Diademoida than in the Cidaridae.

The ambulacra of the Triassic Cidaridae entirely conform to the Cidaroid type. That of *Triadocidaris persimilis* has been described minutely (pp. 72, 73), and a fragment apparently belonging to a *Miocidaris* is also described (p. 93).

The Triassic ambulacra that are here referred to the Diademoida, on the other hand, are still far from having attained the characteristic structure. Of *Mesodiadema* unfortunately we have no certain ambulacrum, but, as stated in the diagnosis of the genus, the ambulacrals are still distinct and in simple series; in the genotype *M. Marconissae* the ambulacra are relatively narrow, and the only feature that suggests a Diademoid relationship is the incipient peripodium in which each pore-pair lies. «Ces ambulacres» says DE LORIOL (1882) «se rapprochent beaucoup de ceux des *Cidaris.*» The phrase in the generic diagnosis, «ambulacrals never tuberculate» («Ambulacralzonen nur granulirt» NEUMAYR) must not be understood to mean more than that the ambulacra bear no tubercles approaching primary tubercles in size. DE LORIOL's statement, no less than his figure *1b*, copied by NEUMAYR, shows that each ambulacral bears an admedian tubercle and miliary quite as distinct as those in *Triadocidaris persimilis.* AIRAGHI (1905, p. 2) says of his *Mesodiadema Lamberti:* «Ambulacri stretti, diritti, colla zona interporifera coperta di granuli, tra i quali uno o due sulla faccia superiore si sviluppano in modo tale da raggiungere quasi le dimensioni dei tubercoli interambulacrali». Of course in the adapical region (sulla faccia superiore) the primary tubercles of the interambulacrals (tubercoli interambulacrali) are not very large, so that if each perradial tract (zona interporifera) only bears one or two approaching them in size, it would seem that this species really has the ambulacral tubercles less developed than has *M. Marconissae.* The obscurity of Dr. AIRAGHI's figures and the ambiguity of his comparison with *M. Marconissae* prevent me from using them to check the correctness of my interpretation.

The two Diadematoid ambulacra from the Cassian beds of Sections XI and VI (pp. 125—127, Pl. IX, figs. 214—217) are particularly interesting in this connection. The primary ambulacrals and their pore-pairs are still in simple series, and, so far as the sutures are visible, the plates appear equal in size; the ambulacra also retain the streptosomatous union with the interambulacra characteristic of most Triassic Cidarids. On certain plates, however, the tubercles have grown larger and extend across the suture on to the adjacent ambulacrals. There is no trace of an arrangement of the plates in triads, or of the pore-pairs in arcs of three, since the distribution of the larger tubercles is rather irregular, and, where most regular, they correspond with two rather than with three plates. The ambulacrum γ from the Raiblian beds of Jeruzsálemhegy has the larger tubercles more pronounced, but still irregular; it further approaches the Diademoids in the conjugation of its pores. In both β and γ the pore-pairs are nearer the oblique position found in the Diademoida than they are in the other ambulacra from Bakony. It should of course be remembered that this obliquity of the pore-pairs is found in some Cidarids, especially in the adoral region, while it is not manifest in several true Diademoids.

The further evolution of the Diademoid ambulacrum through the Liassic species need not here be followed. There also the several features may be seen in various stages of development, and to some of them allusion has already been made in the preceding pages. The two points of importance arising from the present study are, first, that the Diademoid modification had already begun in Cassian times; second, that these earlier forms show an obvious resemblance to the ambulacra of *Triadocidaris* and *Miocidaris.*

The relations of the interambulacrals in many Diademoida have already been discussed at great length (see especially pp. 102—117). It has been shown that the streptosomatous union of the interambulacra with the ambulacra passed up into the Liassic *Diademopsis;* it is known also to occur in the «*Cidaris*» *olifex*, *C. amalthei*, and *C. arietis* of Quenstedt, species which on other grounds appear to approach, if they do not actually belong to, the Diademoida. This fact, then, suggests forcibly a descent of the Diademoida from the primitive streptosomatous Cidarids of the Permian and the Trias.

As regards the general shape and ornament of the interambulacrals, no definite statement can be made. In several early species of *Hemipedina* these plates frequently have a Cidarid appearance. There is, however, nearly always to be detected some trace of secondary tubercles (other than scrobicular), and there is correlated therewith an approach of the primary tubercles to the adradial margin, as well as a general widening of the plates. The fossils referred by various writers, including myself, to *Mesodiadema* have generally been placed in the Diademoida owing to this width of the interambulacrals, and the excentricity of their tubercles, rather than for any more fundamental reason. The reference to *Diademopsis* of the interambulacral fragment described on p. 124 is made on the same grounds, as well as on the still plainer evidence of serially arranged secondary tubercles. This remarkably interesting fragment, to whatever genus it may ultimately be referred, offers as convincing evidence as any other fossil herein described of an intimate connection with the Cidaridae, both in the denticulate adradial margin and in the remains of the interradial auricle. It further bears upon the view elsewhere expressed (p. 116) that *Diademopsis* arose independently of *Hemipedina* and probably at an earlier period.

In short, then, we have seen that, whatever feature preserved in these fossils be taken, each shows a gradual progress from the Cidarid to the Diademoid plan of structure. The hypothesis that the Diademoida and the remaining Ectobranchiata were derived from the Cidaridae, however improbable it may at first have appeared, seems now to have a firm foundation.

3. Systematic.

In this memoir there are described about 23 species and varieties of Crinoids, about 45 of Echinoids, and one Asteroid. The numbers cannot be given with precision owing to the doubtful nature of several fragments; further the number for Echinoidea is excessive, since the radioles are treated separately from the fragments of test. Of new species there are 6 in Crinoidea, 9 based on tests of Echinoidea, and three based on radioles. The Crinoids fall into the Families Encrinidae and Pentacrinidae; the Echinoids into the Tiarechinidae?, Cidaridae, Acrosaleniidae?, and Diadematidae (s. lat.). The material throws no particular light on the limits of the Families, and what bearing it has on their ordinal relations has already been discussed for the most part in the previous section of this summary. Here attention may be directed to a few of the results concerning genera and species.

Under *Encrinus* will be found a discussion of various species, especially *E. cassianus* (p. 9), *E. granulosus* (p. 11), and *E. silesiacus* (p. 14). There seems to have been some confusion between the last-mentioned and *E. radiatus* Schaur., and the latter is here regarded as an early stage of *Balanocrinus* (p. 16).

The morphological importance of the stem-fragments known as «*Pentacrinus* *venustus*» has already been pointed out; their systematic relations are perhaps closest with *Holocrinus* (p. 22.).

The other Triassic species heretofore generally referred to *Pentacrinus* are discussed (pp. 23, 30, 31): *P. subcrenatus* and *P. laevigatus* are referred to *Balanocrinus; P. amoenus, P. bavaricus, P. propinquus* (including *P. Braunii* and *P. Fuchsii*), and *P. tyrolensis* are referred to *Isocrinus.* Of all these, only the last is found in Bakony, and then in somewhat modified forms, causing the erection of a new subspecies, *I. tyrolensis major. Isocrinus propinquus* is more fully discussed on p. 54, and various fossils that have been referred to it are shown to differ in important features; in fact the name *Pentacrinus propinquus*, as found in published lists, cannot be held to imply more than a medium-sized quinquelobate stem of *Isocrinus.* The new species from Bakony are the Cassian *I. candelabrum, I. scipio*, and *I. sceptrum*, and the Raiblian *I. Hercuniae.*

Revised diagnoses of the Family Tiarechinidae and of its two genera *Tiarechinus* and *Lysechinus* are published (pp. 67, 68), and the Family is referred to the Cidaroida with the suggestion that it may be descended from the Lepidocentridae.

In discussing the relationship of the Tiarechinidae, I did not think it necessary to consider any possible descendants of the Family, but tacitly accepted Dr. J. W. Gregory's view that these forms constituted a specialised off-shoot from the main stem, adapted to the peculiar conditions of Triassic time, beyond which they did not persist. Mr. A. Agassiz, in the passage previously referred to (p. 66), had at an early date (1883) compared *Tiarechinus* to the young stages of *Podocidaris*, a recent Arbaciid. In so far as *Tiarechinus* is an example of retarded development, with its ambulacral system permanently in a stage characteristic of immature Echinoids, this comparison is illuminating; but, since it did not appear to involve any belief in a descent of the Cainozoic and Recent Arbaciidae from the Triassic *Tiarechinus*, it had, I supposed, no bearing on the systematic position of the Tiarechinidae. Since those pages were in type, however, Prof. L. Doederlein has emphasized this comparison (1905, Zool. Anzeiger, XXVIII, p. 622; and Nov. 1906, «Echinoiden der deutschen Tiefsee-Expedition», p. 183), and, while separating *Podocidaris prionigera* as a new genus *Pygmaeocidaris*, he says: «ich finde die Ähnlichkeit von *Pygmaeocidaris*... mit dem *Tiarechinus* aus der Trias so ueberraschend gross, dass ich nicht mehr daran zweifeln kann, dass diese beiden Formen nähere Verwandtschaftsbeziehungen miteinander haben müssen, bezw. dass *Tiarechinus* in die Nähe der Arbaciidae gehört».

The points of resemblance, as stated by Doederlein, are: small size of test; relative size and constitution of the apical system; situation of the gonopores; restriction of primary interambulacral tubercles to the ambitus and adoral surface of the test; the presence of unpaired interambulacrals, stretching from the peristome upwards along the interradius, and bearing unpaired main tubercles.

The alleged points of resemblance may first be considered. Size of course is immaterial. The constitution of the apical system in both *Tiarechinus* and *Pygmaeocidaris* is the normal one for Regular Endocyclic Echinoids; such resemblance as obtains between the two genera depends merely on the large proportions of the system in *Pygmaeocidaris*, where, however, its diameter is 0·67 that of the test, while in *Tiarechinus*, according to Lovén's figures, it is 0·84. The situation of the gonopores in *Tiarechinus* is not certain: two only of the genital plates bear round markings, which Lovén merely suggested might be gonopores. The disappearance of primary tubercles from the supra-ambital region is no rare phenomenon, and may be seen even in some Upper Cretaceous Cidarids; moreover the restriction of these tubercles is so much more marked in *Tiarechinus* than in *Pygmaeocidaris* that this can scarcely be considered as a point of resemblance. In any case their distribution depends to a large extent on that of the plates supporting them, and here we must recognise a considerable difference between *Tiarechinus* with its four interambulacrals and *Pygmaeocidaris* with fifteen. *Lysechinus*, if Gregory's interpretation be correct, has. nine interambulacrals, but Doederlein does not consider it so comparable with *Pygmaeocidaris*. The really important resemblance between *Tiarechinus* and *Pygmaeocidaris* seems then to lie in the presence of unpaired median interambulacrals. In *Tiarechinus* the proximal interambulacral is retained, and supports one other unpaired plate reaching up to the genital plate. In *Lysechinus* there are said to be two other unpaired plates, but they are separated from the proximal plate by the ingrowth of the first plates of the *a* and *b* columns. In *Pygmaeocidaris* the proximal interambulacral, which bears a tubercle, is succeeded by a small unpaired plate without a tubercle, and this again by a large tuberculiferous median plate. Now, while the mere possession of unpaired plates is common to the Tiarechinidae and to *Pygmaeocidaris*, there are in the disposition of those plates differences that seem of some importance. The proximal interambulacral in *Pygmaeocidaris* does not stretch across the whole interambulacrum as in Tiarechinidae, but lies between the gill-notches, which are excavated in the first paired interambulacrals. The median interambulacral series does not reach the apical system as in Tiarechinidae, but is separated from it by three pairs of interambulacrals. The two upper plates of the median series do not, as in Tiarechinidae, range horizontally with the adjacent plates of the paired series, but alternate with them. The sutures between the successive median plates are not horizontal as in Tiarechinidae, but slanting; and a still more notable departure from bilateral symmetry is manifested by the uppermost plate shown in Doederlein's fig. 37, and described by him as «nach der einen Seite mehr verbreitert als nach der anderen und erreicht dort mit einer Spitze gerade noch das Ambulacralfeld, indem sie die beiden paarigen Platten dieser Seite auseinander schiebt». The plate in question may very well be the 4th of the *a* column, counted from the adapical end. If the interambulacrum be reconstructed with this plate in the normal position, it will be necessary to stretch *b* 4 across so as to fit in between *a* 4 and *a* 5. It will then be seen that the median plate below it, which bears no tubercle, can naturally be interpreted as *b* 5, similarly squeezed into the middle line, but retaining its position between *a* 5 and *a* 6. Below *a* 6 follows *b* 6 in its natural position above the proximal interradial plate. The other genera of Arbaciidae that retain the proximal or primary median interambulacral in the neanic or the adult stages show no trace of the upper series of median plates, but examination of the very clear figures of *Arbacia* and *Dialithocidaris* published by Mr. Agassiz (1904 «Panamic Deep Sea Echini», pl. liv, ff. 2, 5, 6; pl. xxiii, ff. 1, 4, 5, 6) shows how the interambulacrals are already very oblique and how further pressure in an adoral direction along the adradial tracts would tend to force the inner tuberculiferous portion of some plates into a more interradial position. The extreme widening of the interambulacrum in this manner just at the ambitus in *Pygmaeocidaris prionigera* is in harmony with the very depressed shape of the test. A further result of this shifting of the plates (if such it be) is to bring the normally alternating interambulacrals of the adoral surface into an opposite and paired position, and to increase the number of main tubercles about and below the ambitus. Thus the long radioles with their serrated edges form a framework supporting the animal on the surface of the ooze.

The one point of resemblance that survives criticism is the persistence of the primordial median interambulacral in the adult of both genera. But this is a character shared by *Pygmaeocidaris* with other Arbaciid genera, and in its other Arbaciid characters that genus by no means approaches *Tiarechinus*. The chief differences, admitted by DOEDERLEIN, are: the far greater number of interambulacrals in *Pygmaeocidaris*; and the persistence of primary ambulacrals in *Tiarechinus*, as opposed to the formation of diademoid and arbacioid majors in *Pygmaeocidaris*. DOEDERLEIN considers the alleged absence of external gills in the Tiarechinidae to be an arbitrary assumption, and holds that a contrary conclusion may be drawn from the published figures of the fossil forms; but in this he seems to be carried away by his hypothesis. Whether *Pygmaeocidaris* agrees with other Arbaciidae in the development of knobs and sockets on the joint-faces of its interambulacrals, has not been stated.

Professor DOEDERLEIN's hypothesis manifestly demands that *Pygmaeocidaris* shall be regarded as the most primitive of known Arbaciidae. Now the Family contains about six genera, of which four are known only from Recent seas and the remaining two, *Arbacia* and *Coelopleurus*, do not ascend beyond the Eocene. It is, as anyone would naturally expect, these two genera of greater antiquity that more nearly approach the Jurassic and Cretaceous Hemicidaridae, from which they are in all probability descended. In just those features that have given rise to the comparison with *Tiarechinus*, *Pygmaeocidaris* appears to be the most specialised rather than the most primitive of the Arbaciidae. To prove the contrary, one demands evidence from a series of intervening forms. But all the evidence from those Mesozoic and Cainozoic genera that have been regarded as ancestors of the modern Arbaciidae points in the contrary direction.

The Tiarechinidae became specialised at an early period, when the ambulacrals were still simple primaries, before external gill-notches had developed, and possibly before the additional interambulacral columns found in Palaeozoic Echinoids had been suppressed. But in their specialisation they proceeded much further than any recent Arbaciid. Their interambulacrals were more reduced, their plates more firmly fused, their apical system relatively enlarged, and the radioles still more restricted to the oral surface. *Pygmaeocidaris* is far advanced in all the characters of the Arbacina, but has not fully attained the peculiar Tiarechinid characters. Therefore I regard these latter characters as independently acquired by it, and in no way as ancestral. Between the earlier Arbacina and the Tiarechinidae there is no particular resemblance; and while study of recent Arbaciidae may elucidate the mode of life of their Triassic homoeomorphs, I fail to see that it can cast any light on the affinities of the latter.

The genus *Triadocidaris* is rediagnosed (p. 69), with *T. subsimilis* (MÜNST.) as genotype, and of it three new species are described: *T. persimilis* related to *T. subsimilis*, *T. praeternobilis* related to *T. subnobilis*, and *T. immunita* which shows resemblances to both *Anaulocidaris* and *Mesodiadema*.

Miocidaris is discussed at length (p. 83) and rediagnosed with *M. Cassiani* as genotype, that name being proposed for *Cidaris Klipsteini* DESOR non MARCOU. This proposal and a part of the discussion has, since those pages were in type, been published in a separate paper on *Eocidaris* (BATHER, Jan., 1909, not 1908 as quoted on p. 86). In the course of this discussion, as also in the paper just mentioned, *Eocidaris* is restricted to *E. laevispina* and *E. scrobiculata,* the former being taken as genotype (p. 86). *Cidaris Keyserlingi,* which has very generally been regarded as an *Eocidaris*, is now referred to *Miocidaris*, and *Eotiaris* LAMBERT is therefore not accepted (p. 85). A number of fragments are referred to *Miocidaris*, but for only two forms are new names proposed — *M. verrucosus* and *M. planus.*

The discovery of interambulacral plates that, it is believed, belong to the same species as the radioles described as *Anaulocidaris testudo,* has caused the resuscitation of that genus as a peculiar type of Cidarid (pp. 94, 138).

An interambulacral fragment from the Cassian beds of Cserhát that seemed to resemble the description of *Eodiadema granulatum* led to a discussion of the genus (p. 100). It was not till the sheet containing those remarks was already completed that I discovered the original specimens of *Eodiadema,* just in time to insert a brief statement. Further specimens have since been placed in my hands, and I hope to publish a separate account. In the remarks on the type-species I have nothing to alter, but I now think that the reference of the fragment from Cserhát to *Eodiadema* is more than doubtful.

In order to understand the relations of various Diademoid fragments from Bakony, I studied the genera with which comparison seemed likely to be profitable, and some of the results of this study are summarised on pages 102—117. The genera chiefly discussed are: *Archaeodiadema* GREGORY, which seems to me a *Hemipedina; Palaeopedina* LAMBERT, which also appears insufficiently distinguished from the same genus; *Orthopsis* COTTEAU, which I am led to regard as a post-Bajocian modification of *Diademopsis,* and not so primitive as has been supposed; *Hemipedina* WRIGHT and *Diademopsis* DESOR, which do really seem to represent two distinct lines of descent, although repeated modifications render it difficult to assign every species to its correct genus; this difficulty of discriminating the genera has been expressed by almost every writer on the subject, and the proposal to retain the prior *Hemipedina* as the main genus in a broad sense, while referring certain species to *Hemipedina* (s. str.) and *Diademopsis* as subgenera, will, it is hoped, serve practical convenience until our knowledge is further advanced. Finally *Mesodiadema* NEUMAYR receives fairly full discussion, but without examination of the various original specimens (such as time did not permit me to undertake) this cannot pretend to finality. The result of this comparative study is that two Raiblian species from Bakony are referred to *Mesodiadema — M. margaritatum* and *M. latum* — and one is regarded as an ancestral form of *Diademopsis—Hemipedina (Diademopsis) incipiens. Mesodiadema latum,* as subsequently pointed out (p. 229) appears to include the interambulacral fragment doubtfully referred by VON WÖHRMANN to his *Cidaris Schwageri,* but whether it is conspecific with the radiole that is the holotype of that species must remain undecided; it seems more probable that its radioles in Bakony are represented by some of the forms here described as *Radiolus lineola* (p. 234).*

The Radioles of Triassic Echinoidea, especially the numerous forms from St.

* It is unfortunate that in this study of the Diademoida I had not the advantage of Dr. A. TORNQUIST's valuable paper «Die Diadematoiden des württembergischen Lias». (Zeitschr. deutsch. geol.

Cassian, have been a perpetual source of trouble to systematists. A final solution of the difficulty cannot be expected until every known form shall have been found in unmistakeable association with a determinable test. Since, however, such discoveries are not likely to be numerous, we have to do the best we can with other methods. There are two lines of attack that promise an advance. One is the study of the variations due to position on the test or to individual growth, and the comparison of large series, with the aid of biometry when possible. These methods are discussed on pages 136—138, and a concrete illustration of them is afforded by the study of a large series of radioles differing greatly in form, but all referred to a single species, *Anaulocidaris testudo*, and all distinguished from those of the corresponding, though less complete, series referred to *A. Buchi.* The second mode of attack is the study of thin sections under the microscope, as lately developed by Dr. Hesse (1900). The application of this method in combination with the preceding, as well as the careful study of type-specimens, has enabled me to formulate conclusions on a rather wider basis of fact than has previously been attempted.

These studies have led me to investigate many forms of radiole not actually known from Bakony, and a few of the results are mentioned in the preceding pages. It may therefore be useful to give here a brief synopsis of the species accepted, with their chief synonyms. The name *Cidaris* is used for certain species, merely because it nearly always has been used, and it must not be taken to connote more than the Cidarid nature of the radiole.

Anaulocidaris Buchi (Münst. in Goldf.) (p. 155)
Syn. *Cidaris remifera* Münst.
Var. *A. Buchi granulata* mut. nov.
Anaulocidaris testudo n. sp. (pp. 94, 140)
Cidaris alata Ag. (p. 170)
Syn. *C. semicostata* Münst.
Varr. *C. alata typica*
C. alata subalata d'Orb.
C. alata poculiformis mut. nov.
Cidaris d'Orbignyiana Klipst. non *C. Orbignyana* Ag. (p. 171)
Synn. *C. Klipsteini* Marcou non Desor
C. ampla Desor
Cidaris austriaca Desor (p. 171)
Syn. *C. ovifera* Klipst. non Ag.
Cidaris dorsata Münst. ex Bronn MS. (p. 178)
Synn. *C. foratus* Quenst.
Radiolus crumena Quenst.
Varr. *C. dorsata typica*
C. dorsata marginata mut. nov.
Cidaris scrobiculata Braun in Münst. (p. 183)
Cidaris fustis Laube (p. 184)
Cidaris decorata Münst. (p. 185)
Cidaris fasciculata Klipst. (p. 187)
Syn. *C. avena* Desor.

Ges. LX, pp. 378—384, pls. xv—xix, Nov. 1908, and pp. 385—430, 1909). In so far as our conclusions agree, their absolute independence will give them the more weight.

Cidaris similis DESOR (p. 188)
Synn. *C. baculifera* AG., MÜNST., non *C. bacculifera* AG.
C. Braunii DESOR var. *C. baculifera* MÜNST., AGASSIZ & DESOR, non *C. Braunii* DESOR.
Cidaris Waechteri WISSM. in MÜNST. (p. 191)
Synn. *C. catenifera* AG., MÜNST., non AG.
C. Braunii DESOR in AGASSIZ & DESOR, excl. var. *baculifera.*
Cidaris Wissmanni DESOR in AGASSIZ & DESOR (p. 195)
Syn. *C. spinosa* AG., MÜNST., non. AG.
Var. nov. *C. Wissmanni rudis*
Cidaris Hausmanni WISSM. in MÜNST. (p. 201)*
Varr. *C. Hausmanni typica*
C. Hausmanni tofacea mut. nov.
Cidaris parastadifera SCHAFH. (p. 207)
Syn. *C.* cf. *marginata* SCHAFH.
Cidaris decoratissima WÖHRM. (p. 213)
Radiolus raiblianus n. sp. (p. 216)
Radiolus penna n. sp. (p. 218)
Cidaris trigona MÜNST. (p. 219)
Synn. *C. imbricata* CORNALIA
C. truncata CORNALIA
Radiolus complanatus QUENST. (p. 224)
Cidaris Roemeri WISSM. in MÜNST. (p. 224)
Synn. *C. tyrolensis* DESOR
C. spinulosa KLIPST. non F. A. ROEMER
C. subspinulosa D'ORB.
C. perplexa DESOR
Cidaris flexuosa MÜNST. (p. 225)
Synn. *C. cingulata* MÜNST.
C. Brandis KLIPST.
? *C. Petersi* LAUBE
C. undulatus QUENST.
Cidaris Meyeri KLIPST. (pp. 226, 234)
Cidaris linearis MÜNST. (p. 227)
Syn. *C. bicarinata* KLIPST.
Cidaris Schwageri WÖHRM. (p. 228)
Radiolus lineola n. sp. (p. 230)
Varr. *R. lineola major*
R. lineola minor
Cidaris grandaeva ALBERTI ex GOLDF. MS. (p. 233).

* In discussing (p. 212) the supposed nomen nudum *Cidaris Klipsteini* GÜMBEL (1861), it should have been added that the name was used by KLIPSTEIN himself (1883, pp. 47, 50) for radioles from Cassian beds at the Stuores and Prolongei; but he added «zum Theil *Hausmanni*». Since the KLIPSTEIN collection in the British Museum was purchased in 1861, it naturally contains no specimens labelled with this name; those so labelled in the KLIPSTEIN collection at Budapest are probably the chief evidence for KLIPSTEIN's record. They may have been intermediate in position on the test between the radioles named *C. Hausmanni* and *C. similis.*

4. Nomenclature.

During the progress of this work various questions of nomenclature have presented themselves, or have been raised by others. With most of these I have attempted to deal in special papers, but it will be convenient to give a brief summary here.

The name *Encrinus* has had a curious history, but for about a century it has been generally if not universally used for the well known Stone-lily of the Muschelkalk, to which it was applied by LACHMUND (1669) and his successors. Indeed, though isolated portions of the *Lilium lapideum* may have received special names, the fossil as a whole has never been called anything but *Encrinus* or *Encrinites*. Naturally, before detailed study led to the discrimination of the various genera of Crinoidea, the name *Encrinus* was often extended to other fossils now known by distinctive names. Similarly, when living stalked crinoids were first dredged in the Caribbean Sea, and when it was recognised that they belonged to the same class of animals, they also were provisionally called *Encrinus*. In this sense, as has already been noted on p. 30, we find the name *Encrinus* applied by ELLIS (1762), BLUMENBACH (1779—1807), and others. But, as reference to those writers will show, they had no intention of removing the accepted name from the Triassic fossil to the recent animal. Unfortunately the earlier systematic works in which a binominal Latin nomenclature was used, beginning with the tenth edition of LINNAEUS (1758), dealt almost entirely with recent animals, so that the chance of *Encrinus* being legitimized in its usual sense was seriously diminished.

Consequently Mr. Austin H. CLARK, who has recently attempted to apply the modern rules of nomenclature in a very rigid manner (1908, 1909), maintains that *Encrinus* should be ascribed to BLUMENBACH (1779) with *Isis asteria* LINN. as genotype. Mr. Frank SPRINGER, however, in a weighty paper (1909) points out that ANDREAE (1763) formally proposed the name *Encrinus coralloides* for certain fossils, and that (if no prior use can be found) the name *Encrinus* must be ascribed to ANDREAE and interpreted according to the fossils mentioned by him. Unfortunately, both Mr. CLARK (1908) and Mr. SPRINGER (1909) quote ANDREAE incorrectly. ANDREAE'S reference to D. BRÜCKNER'S «Merkwürdigkeiten der Landschaft Basel» is not to «Part 6» as stated by Mr. CLARK, nor to «Table 8 of the eighth Stueck» as Mr. SPRINGER says, but to «die in dem siebenten Stücke... beschriebene und auf der siebenten Tafel abgebildete Corallenschwämme», namely «die sechs Stücke g. h. i. k. l. m». This plate, with the description, not by BRÜCKNER but, as both BRÜCKNER and ANDREAE testify, by Joh. Jakob BAWIER, was published in 1752. The fossils denoted are not those mentioned by DE LORIOL in his «Crinoides fossiles de la Suisse» and referred by him to *Millericrinus echinatus*. They are thick stem-fragments or branching roots of various species of Apiocrinidae, but to which species or even to which genus they should be referred cannot, in my opinion, be determined from the figures and descriptions, and the silence of DE LORIOL on the matter indicates that he shared that opinion.

If then it were necessary to accept *Encrinus* ANDREAE, the conclusion would not be that drawn by MR. SPRINGER. If interpreted by the fossils referred to, the name would be merely a published name, based on an indeterminable species, and therefore incapable of being used in that or any other sense. But if interpreted by ANDREAE's own words in the same sentence and elsewhere on the associated pages, it is clear that by «*Encrinus*» ANDREAE in the first place understood the «Lilienstein», just as ELLIS did, and just as BLUMENBACH did.

Further evidence as to the contemporary use of «*Encrinus*» is afforded by J. HOFER (1760 «De Polyporitis vel Zoophytis petrefactis», Acta Helvet. IV). In the learned account of his genus *Anthoporita*, he comes (p. 204) to the list of «*Entrochi florales* sive *Encrini*», and these are illustrated by various figures of undoubted *Encrinus liliiformis.*

As for the use of *Encrinus* by SCHULZE* (1760), there can never have been any doubt as to his meaning, whether his words or his plates be taken into account; and for this reason it has always seemed to me the simplest and most satisfactory course to credit the name, in its Post-Linnean use, to him. This, with a full knowledge of all the facts, I have done in the earlier pages of this memoir. If the alternative be an ultra-rigid application of the rules, the result would simply be the elimination of the name *Encrinus*, and some-one would have to find another. There might be some advantages in this course, but is it really worth while? Perhaps we should have to use *Flabellocrinites* KLIPSTEIN, perhaps *Chelocrinus* v. MEYER. For further discussion of the general principle, I beg to refer the reader to a paper on «Some common Crinoid Names, and the Fixation of Nomenclature» (Ann. Mag. Nat. Hist., July, 1909).

If the conclusions of Mr. A. H. CLARK (1909) concerning the name *Encrinus* were well founded, that name would have to be employed for the genus including *Isis asteria* LINN. At present most active workers on Crinoidea are agreed to call that genus «*Isocrinus*», and so it is called in the present memoir. For the reasons just given I do not consider that the name *Encrinus* can be applied to it. Various attempts have been made to subdivide the genus yet further, but our knowledge of the Triassic species is not yet enough to enable us to say to which, if any, of those subdivisions they should be referred.

The names *Isocrinus* and *Balanocrinus* are further discussed in my paper on «Some common Crinoid Names &c.» (1909).

Under Echinoidea the name *Echinocrinus* will be observed, used as the equivalent of *Archaeocidaris*. Full discussion of this will be found in my note: «*Echinocrinus* versus *Archaeocidaris*» (Nov. 1907). Here I have only to say that, while there can be no doubt as to the consequences of the rules, this seems to me just one of those cases that should be settled by a properly constituted authority in defiance of the rules.

The application of the names *Eocidaris* and *Miocidaris* has already been mentioned under «Systematic», (p. 260) and full discussion will be found in my paper on *Eocidaris* (Jan. 1909). I am glad to learn that Professor R. T. JACKSON concurs in my treatment of *Eocidaris*, which it seems probable will eventually prove to be a synonym of *Echinocrinus* (= *Archaeocidaris*).

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* «SCHULZE», says Mr. CLARK (1908, p. 517), «was merely repeating the name by which these fossils were known to pre-Linnaean authors», he was merely «a compiler who copied their names». This is rather unfair to one who was not only a zoologist of repute, but who had himself written an important paper on these particular fossils (1756).

LIST OF PAPERS AND WORKS REFERRED TO.

This does not profess to be a Bibliography of Triassic Echinoderms, nor does it even claim to give every paper that mentions Echinoderms in the Trias of Bakony. The bibliographic details, however, have all been carefully checked with the original sources, and this fact seems worthy of mention, since it may account for some of the differences between this and other Lists or Bibliographies; at the same time it does not guarantee entire absence of error.

In a very few cases, where the reference in the text did not appear sufficiently explanatory, an elucidatory note has been added. The pages of this memoir on which any author in the List is quoted may be found from the Index.

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Names of Authors are in capitals, thus	KLIPSTEIN
Names of Geological formations or ages are in roman type with an initial capital, thus	Trias.
Names of Places likewise, thus	Veszprém.
Terms, referred to as such, are in roman type, with a small initial, and between quote-marks, thus	«tubercle».
Structures or subjects dealt with are in roman type with a small initial, thus . .	evolution.
Names of Genera are in italics with an initial capital, thus	*Cidaris.*
Names of Species are indexed under the trivial name (in italics and never with an initial capital) followed by the generic name, thus	*buchi, Cidaris.*
The trivial names of species are also entered in an alphabetical list following the name of each genus with which they have been associated. There is no attempt to indicate which association is considered correct.	
Names of Subspecies, Varieties, and Mutations are dealt with in the same way, but are followed by the complete specific name, thus	*poculiformis, Cidaris alata.*
The Arbitrary signs of distinction α, β, γ, are spelled out, and are followed by the specific or other name to which they refer, thus	*alpha, Miocidaris* sp.
Fragments of which the species is indeterminable are indexed under the name of the genus to which they are referred, thus	*Plegiocidaris* sp.
Under all entries of Systematic names, the number of the page on which the Genus, or Species, or Specimen, is more particularly described or discussed is printed in heavy-faced type, thus	*scrobiculata. Cidaris,* **183.**

LIST OF ILLUSTRATIONS IN THE TEXT.

CORRIGENDA.

p. 17, line 2 from end: for «cutting VI on the Veszprém-Jutas railroad» read «Section VI, at Veszprém».
p. 39, » 1 at top: » » » » » » » » » » » »
p. 43, » 12 from end: » » » » » » » » » » » »
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p. 70, » 22: » » » » » » » » » » » »
p. 76, » 11: » » » » » » » » » » »
p. 18, » 2, 3: for «Felső Eörs» read «Felsőörs».
p. 18. *Dadocrinus*, third reference: for «v. MAJER» read «v. MEYER».
p. 33, line 16 from end: for «fig. 45» read «fig. 44».
p. 33, » 17 from end: for «fig. 44» read «fig. 45».
p. 34, line 21: for «requently» read «frequently».
p. 45, last line: omit «Vamu».
p. 46, line 1 at top: for «Cutting» read «Section».
p. 48, » 2 from end: for «Cutting VII» read «Section VIII»; bed *d* 1, is, I am now informed, a dolomite.
p. 48, line 2, plate-reference: for «103« read «102».
p. 74, line 1: for «124» read «129».
p. 83, line 5 from end: for «heing» read «being».
p. 86, end of third paragraph: for «1908» read «Jan., 1909».
p. 118. Measurements: Diameters of mamelons: for «9.35» read «0.35».
p. 118, line 7 from end: for «*lata*» read «*latum*».
p. 122, third paragraph. Description of specimen *w*, first line: for «202» read «210». Second line: for «Cassian» read «Raiblian».
p. 128, line 9 from end: delete «Muschelkalk». The two portions of pyramids are from the Cserhát group.
p. 133, line 12: for «alveolus» read «maxilla».
p. 134, » 22: for «alveoli» read «maxillae».
p. 134, » 28: for «Muschelkalk» read «Cassian».
p. 149, » 3 from end: for «se ethat» read «see that».
p. 168, » 2: for «Cassain» read «Cassian».
p. 191, footnote 1, line 6: for «Kreidegeb.» read «Oolithengeb.»
p. 194, line 2 from end: for «Pl. 350, figs. 351» read «Pl. XII, figs. 350, 351».
p. 197, » 2 from end: for «themselwes» read «themselves».
p. 218, » 11: for «fig. 51» read «fig. 451».
p. 238, *Miocidaris verrucosus* is from Quarry near Cutting I, not from Cutting I. The totals here and on p, 240 should be altered accordingly.

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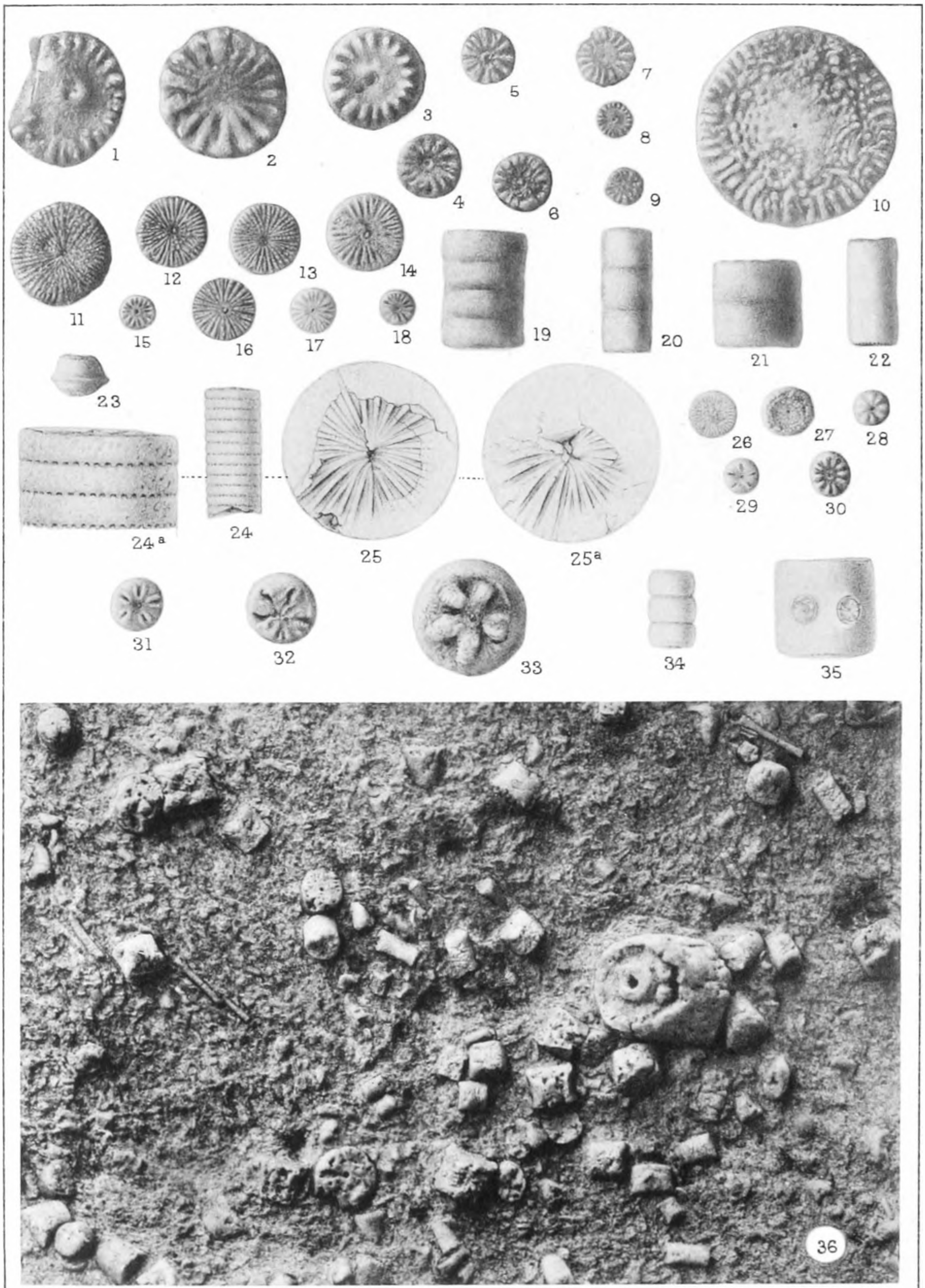

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Encrinus, Dadocrinus, Holocrinus.

PLATE I.

Encrinus cassianus.

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Entrochus sp.

26. Entrochus of two columnals from Cserhát; the better preserved joint-face, × 5·5 diam. 17

Trochita sp.

27. A columnal from Cserhát; joint-face, × 5·5 diam. 17

Dadocrinus? sp.

28. Entrochus of two columnals from Cserhát (perhaps derived from Muschelkalk); joint-face, × 5·5 diam. 19

Entrochus quinqueradiatus.

(Figs. 29—34, from Cserhát. All × 5·5 diam.)

29. Specimen *a*, joint-face with 5 grooves . . 20
30. Holotype *d*, » » » 10 minor ridges . 20
31. Specimen *f*, » » » 5 main grooves and 10 bounding ridges 20
32. Specimen *g*, joint-face with 5 grooves . . 20
33. Specimen *h*, » » » 5 ridges . . . 20
34. Specimen *c*, side-view 19, 20

Entrochus cf. «*Pentacrinus venustus*».

35. Specimen *k*, from Cserhát; side-view showing the two largest cirrus-facets, × 10 diam. 22

Holocrinus sp.

36. Part of the weathered surface of a piece of limestone from Tamáshegy, Balaton-Füred, showing columnals, cirrals, and brachials; also a larger columnal, probably belonging to *Encrinus*; × 4·5 diam. 21

Figures 1—23 and 26—33 are based on photographs by H. HERRING, but have been finished from microscopic examination of the specimens.

Figure 36 is a direct reproduction from a photograph by H. HERRING.

Figures 24, 25, 34, and 35 are from pencil-drawings by T. LEWIS.

PLATE II.

Isocrinus tyrolensis.

Pag.

37. Lecto-holotype, redrawn from the original in Geologische Reichsanstalt, Wien ; a complete intersyzygium, side-view, × 6·3 diam. . . 31
38. The same ; joint-face of the hypozygal, × 6·7 diam. 31

Isocrinus tyrolensis major.

(Figs. 39, 40, 42—47, 49, from Quarry near Cutting I. Figs. 41, 48, 50 from Jeruzsálemhegy.)

39. Large normal joint-face, slightly worn at the interradial angles, × 10 diam. 34
40. Small normal joint-face, × 10 diam. . . . 34
41. Intersyzygium with radial swellings, side-view, × 5 diam. 34
42. Epizygal joint-face, × 10 diam. 34
43. Hypozygal joint-face of same intersyzygium, × 10 diam. 34
44. Holotype, an intersyzygium with 6 internodals, of which the side-faces are hollowed radially, side-view, × 5 diam.
    (referred to on p. 33, line 16 from end, as fig. 45).
45. An intersyzygium with 5 internodals, with smoother side-faces than in the holotype, side-view, × 5 diam.
    (referred to on p. 33, line 17 from end, as fig. 44).
46. An epizygal face somewhat weathered, showing the deep triangular identation for the cirrus-facet, also, in one radius, the cirral nerve-canal leading to the axial canal, × 10 diam. 34

Pag.

47. A cirrus facet of the same, × 30 diam. . . 34
48. An oval cirrus-facet, entirely enclosed by the epizygal, × 30 diam. 35
49. Distal joint-face of cirral 2, × 30 diam. . . 35
50. » » » » » 1, × 30 » . . 35

Isocrinus tyrolensis var. *α*

(Figs. 51—53, 55 and 56, from Quarry near Cutting I.)

51. Specimen *b*, normal joint-face, × 10 diam. . 36
52. Specimen *a*, hypozygal joint-face, × 10 diam. 36
53. Specimen *a*, epizygal joint-face, × 10 diam. 36
55. Specimen *a*, cirrals 1 and 2 (or perhaps 2 and 3) showing distal joint-face of latter, × 30 diam. 36
56. Specimen *a*, the whole intersyzygium, side-view, × 5 diam. 36

Isocrinus tyrolensis var. β.

54. Internodal stem-fragment from Cutting I on Veszprém—Jutas Railway ; normal joint-face, × 10 diam. 37

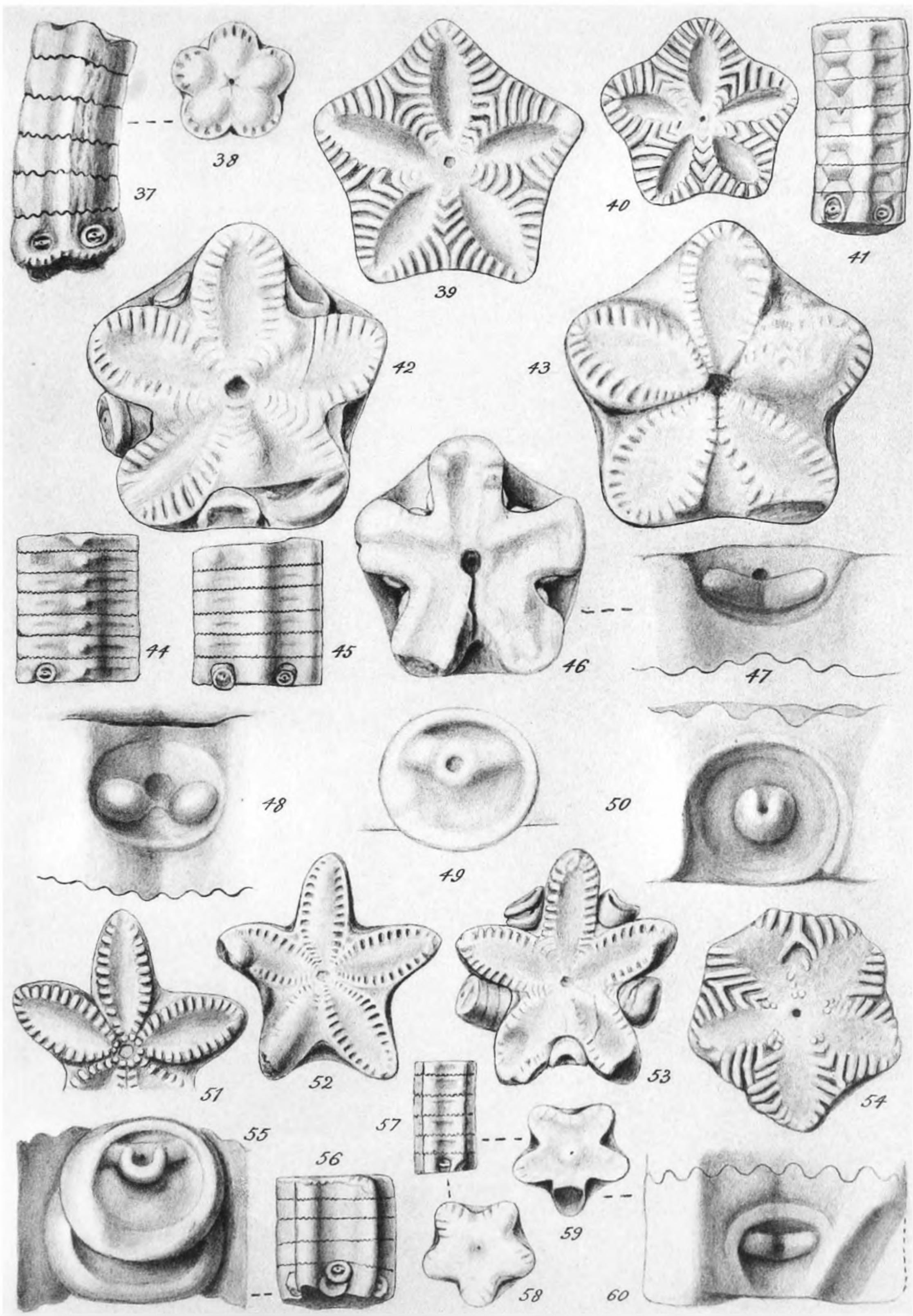
Isocrinus tyrolensis var. γ.

(Figs. 57—60, an intersyzygium from bed *b* 1 of Cutting IV on Veszprém—Jutas Railway.)

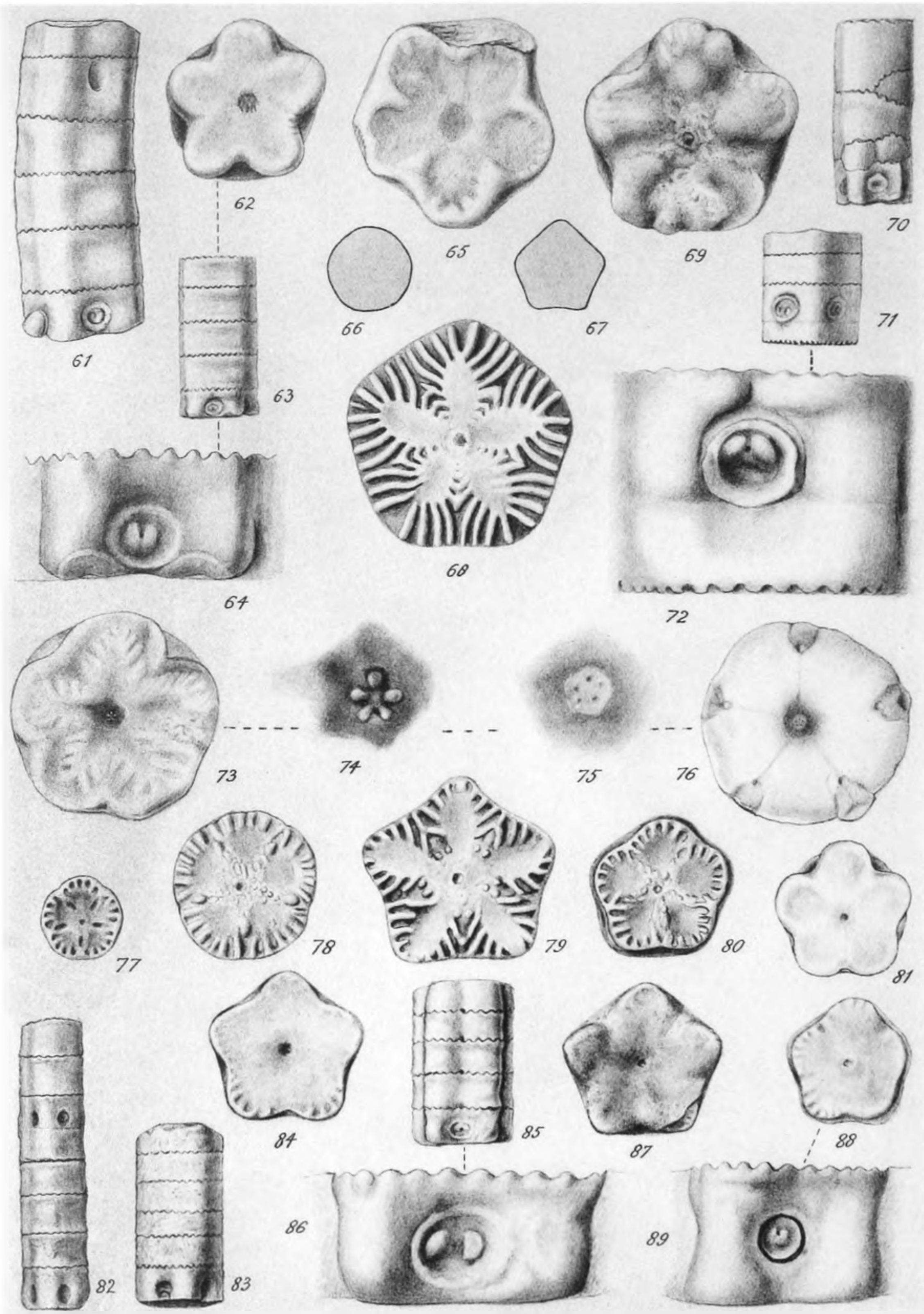
57. Side-view, × 5 diam. 37
58. Hypozygal joint-face, × 10 diam. 38
59. Epizygal joint-face, × 10 diam. 38
60. Cirrus-facet, × 30 diam.

Figures 37 and 38 are from sketches by the Author.

All the other figures were drawn from nature by A. T. HOLLICK.



Isocrinus tyrolensis.



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Isocrinus candelabrum, I. scipio.

PLATE III.

Isocrinus candelabrum.

(Figs. 61—67 and 69—76 represent specimens from Cserhát; Fig. 68. from Jeruzsálemhegy.)

Pag.

61. Specimen *m*, a complete intersyzygium; side-view, × 10 diam. 39
62. Holotype, specimen *c*, syzygial face of epizygal, × 10 diam. 38, 39
63. Holotype, side-view, with the epizygal at the lower end, × 5 diam. 39, 40
64. Holotype, a cirrus-facet, × 20 diam. . . . 40
65. Specimen *m*, syzygial face of hypozygal, × 10 diam. 38
66. Specimen *h*, outline to show the sub-pentagonal transverse section, × 5 diam. 39
67. Specimen *k*, outline to show the sub-concavi-stellate transverse section, × 5 diam. . . 39
68. Specimen *q*, a normal joint-face, × 10 diam. 39, 40
69. Specimen *l*, syzygial face of hypozygal, × 10 diam. 38, 39
70. Specimen *o*, young columnals, showing their relative length, and the intercalation of new columnals, × 10 diam. 41
71. Specimen *g*, a stem-fragment comprising a complete syzygial pair, with cirrus-facets; side-view, × 5 diam. 40
72. Specimen *g*, a cirrus-facet, × 20 diam. . . 40
73. Specimen *p*, an intersyzygium; syzygial face of hypozygal, showing minute specks in axial canal, × 10 diam. 41, 42
74. Specimen *p*, the lumen of the same face, showing the appearance of the specks, × 35 diam. 41, 42
75. Specimen *p*, the lumen ground down on the face of the epizygal, × 35 diam. . . 41, 42
76. Specimen *p*, the epizygal end ground down (cf. text-fig. 5), × 10 diam. 41, 42

Isocrinus scipio.

(Figs. 77—89, all from Cserhát.)

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77. Specimen *a*, young, normal joint-face of sub-pentagonal section, showing grooves for reception of radial ridges, × 10 diam. . . 44
78. Specimen *b*, normal joint-face of sub-quinquelobate section, with single radial ridges, approaching the structure of *Balanocrinus*, × 10 diam. 44
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80. Holotype, specimen *d*, an epizygal viewed from its normal joint-face, in which view the swelling towards the syzygy is plain, × 10 diam. 44
81. Specimen *e*, syzygial face of an epizygal × 10 diam. 44
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85. Specimen *j*, an intersyzygium; side-view, showing slight radial pores, × 5 diam. . 44
86. Specimen *j*, cirrus-facet, × 20 diam. . . . 44
87. Specimen *k*, syzygial face of a hypozygal, × 10 diam. 44
88. Specimen *l*, syzygial face of an epizygal, with traces of crenellae, × 10 diam. 44
89. Specimen *l*, cirrus-facet, × 20 diam. . . . 44

All figures drawn from nature by A. T. Hollick.

PLATE IV.

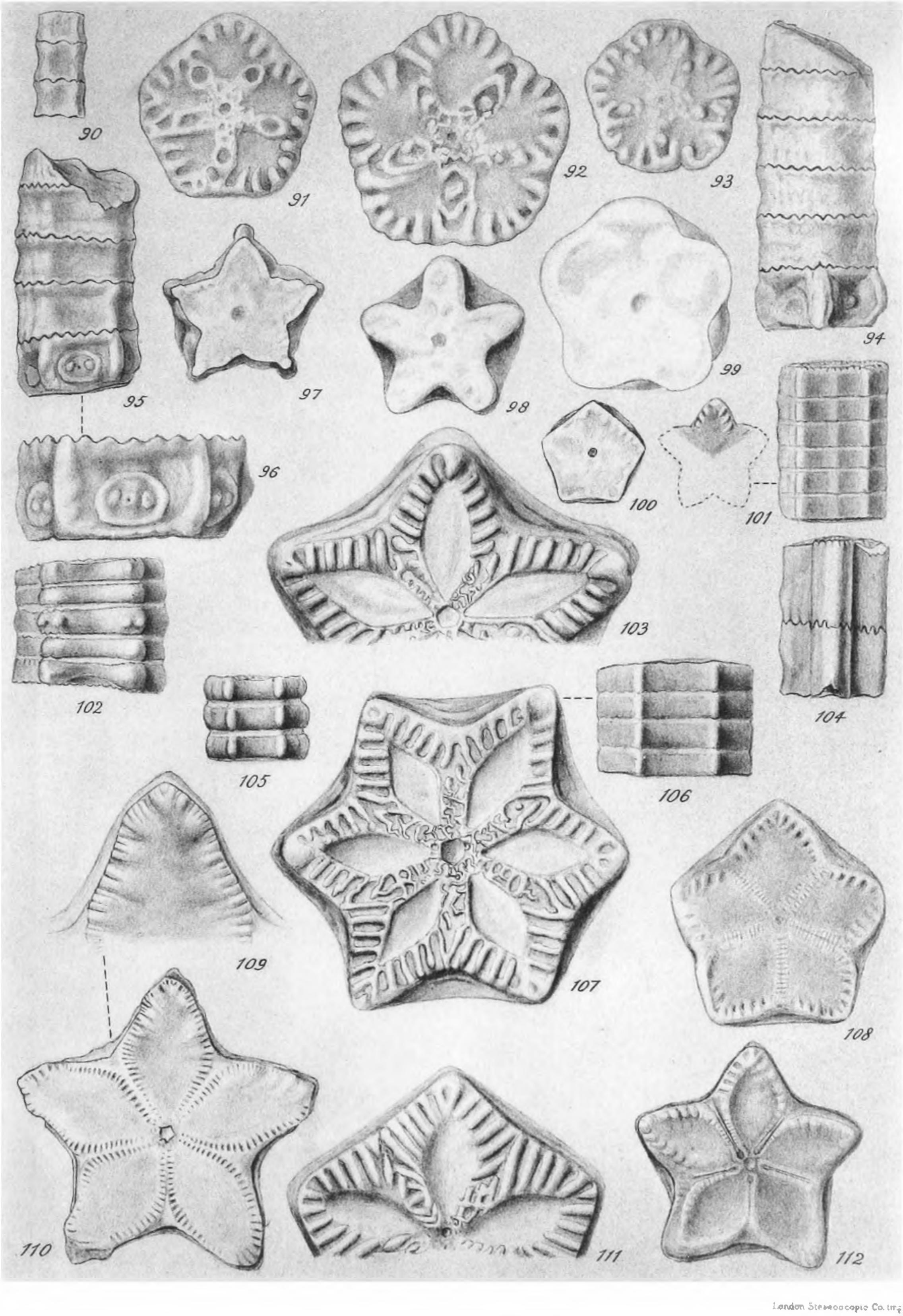
Isocrinus sceptrum.

(Figs. 90—101 all from bed *e* of Section VI, Veszprém.)

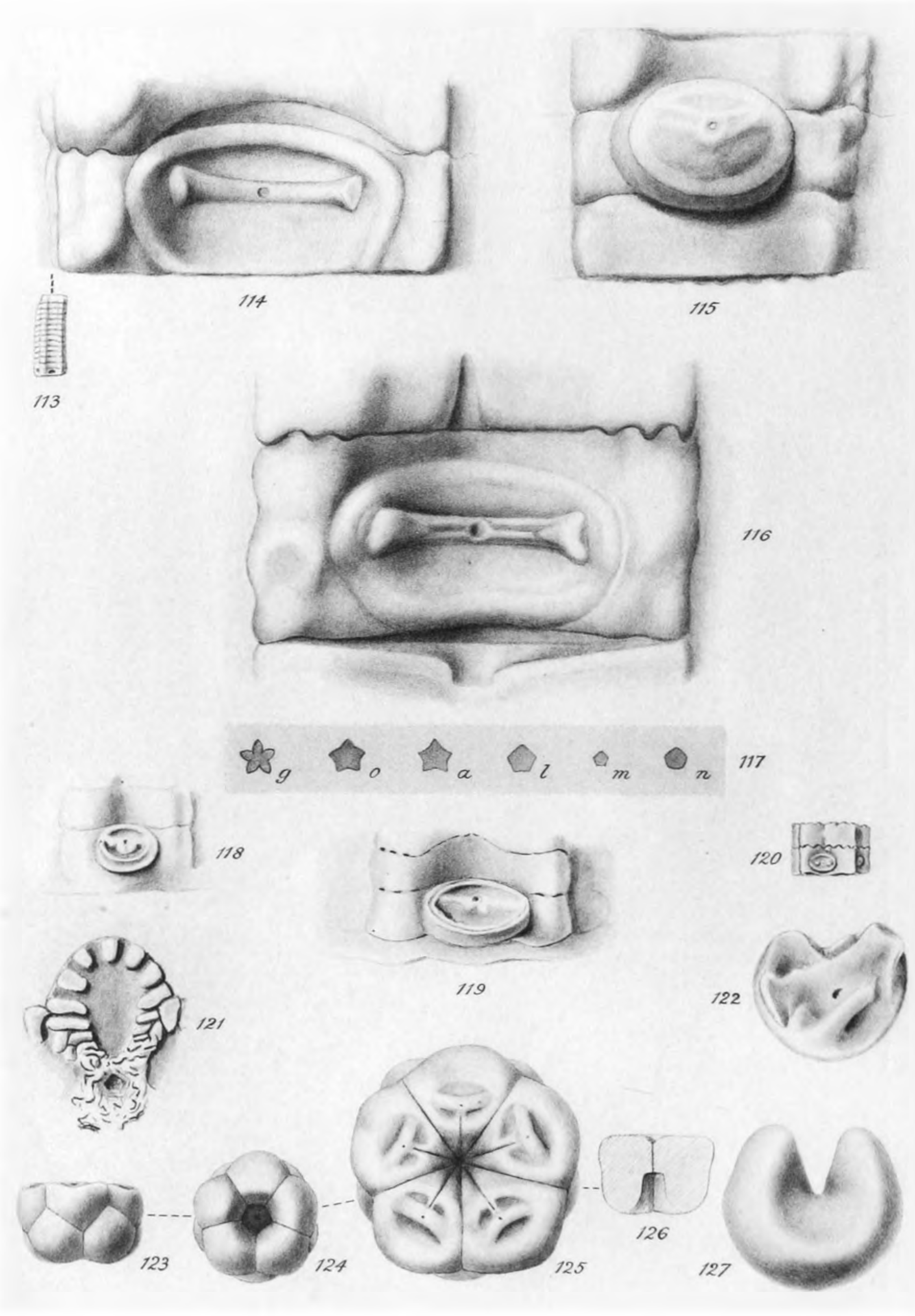
Isocrinus Hercuniae.

(Figs. 102—112 all from Quarry near Cutting I.)

All figures drawn from nature by A. T. Hollick.



Isocrinus sceptrum, I. Hercuniae.



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Isocrinus Hercuniae, I. spp.

PLATE V.

Isocrinus Hercuniae (continued).

(Figs. 113—117, all from Quarry near Cutting I.)

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113. Specimen *e*, fragment consisting of 14 internodals and an epizygal, but not a complete intersyzygium; side-view, nat. size . . . 52
114. Specimen *e*, cirrus-facet, × 20 diam. . . . 52
115. Specimen *f*, distal joint-face of cirral 2, *in situ*, × 20 diam. 53
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Isocrinus propinquus and allied forms.

118. Small specimen from St. Cassian, labelled «*Pentacrinus propinquus*» by LAUBE, perhaps the original of his pl. viii *a*, f. 17 *b* Geol. Reichsanst. Wien. Distal joint-face of cirral 1, × 8 diam. 54
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122. A brachial on the same fragment of matrix as the preceding, × 16·6 diam. 54

Isocrinus scipio ?

123 Patina from Cserhát (Leitnerhof). side-view, × 5 diam. 56
124. The same, from below, × 5 diam. 56
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126. The same, reconstructed median vertical section, × 5 diam.. 56

Isocrinus ? sp.

127. A brachial from Cserhát (Leitnerhof) × 10 diam. 58

Figures 118—122 are from drawings by the Author.

The outlines in figure 117 were directly printed on a slip of paper from the specimens.

The remaining figures are by A. T. HOLLICK.

PLATE VI.

Tiarechinus ?, sp.

Pag.

128. Supposed fragment of an interambulacrum from Cserhát, with the adambulacral border on the right hand, × 3 diam. 68

Triadocidaris persimilis.

(Figs. 129—134 from Cserhát.)

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130. Specimen *c*, interior view of interambulacrum, adoral end uppermost, × 5 diam. . . . 74
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132. Holotype, part of the ambulacrum, showing the precise relation of its plates to the denticles of the interambulacral plate under which it is pushed, × 10 diam. . . . 72, 73
133. Holotype, interambulacrum and ambulacrum from the side, adapical end uppermost, × 3 diam. . . . . 70—73
134. Holotype; the structure of the ambulacrum. and its relation to the denticles, × 20 diam. Compare text-fig. 10 73

Triadocidaris praeternobilis.

(Figs. 135—138, all × 5 diam.)

135. Specimen *b*, from Cutting I, Veszprém—Jutas Railway. Two interambulacrals, external view, adradial margin on left hand . . 76, 77
136. Specimen *b*, internal view, adradial margin on right hand. 76, 77
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138. Holotype, part of an interambulacrum from Jeruzsálemhegy; external view and elevation of a main tubercle. . . . . 76—77

Triadocidaris cf. *T. praeternobilis.*

139. Specimen *a*, an interambulacral from Jeruzsálemhegy; external view, × 5 diam. . . . 78
140. Specimen *a*; side-view from transverse margin, × 5 diam. 78

Triadocidaris immunita.

(Figs. 141 - 149. All from Jeruzsálemhegy.)

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141. Holotype, specimen *a*; adoral end of an interambulacrum, external view, × 3 diam. . . 80
142. Holotype, side view, adoral end on right hand, × 3 diam. 82
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Miocidaris sp. indet. *a*

(Figs. 150—152, from Cserhát. All × 5 diam,)

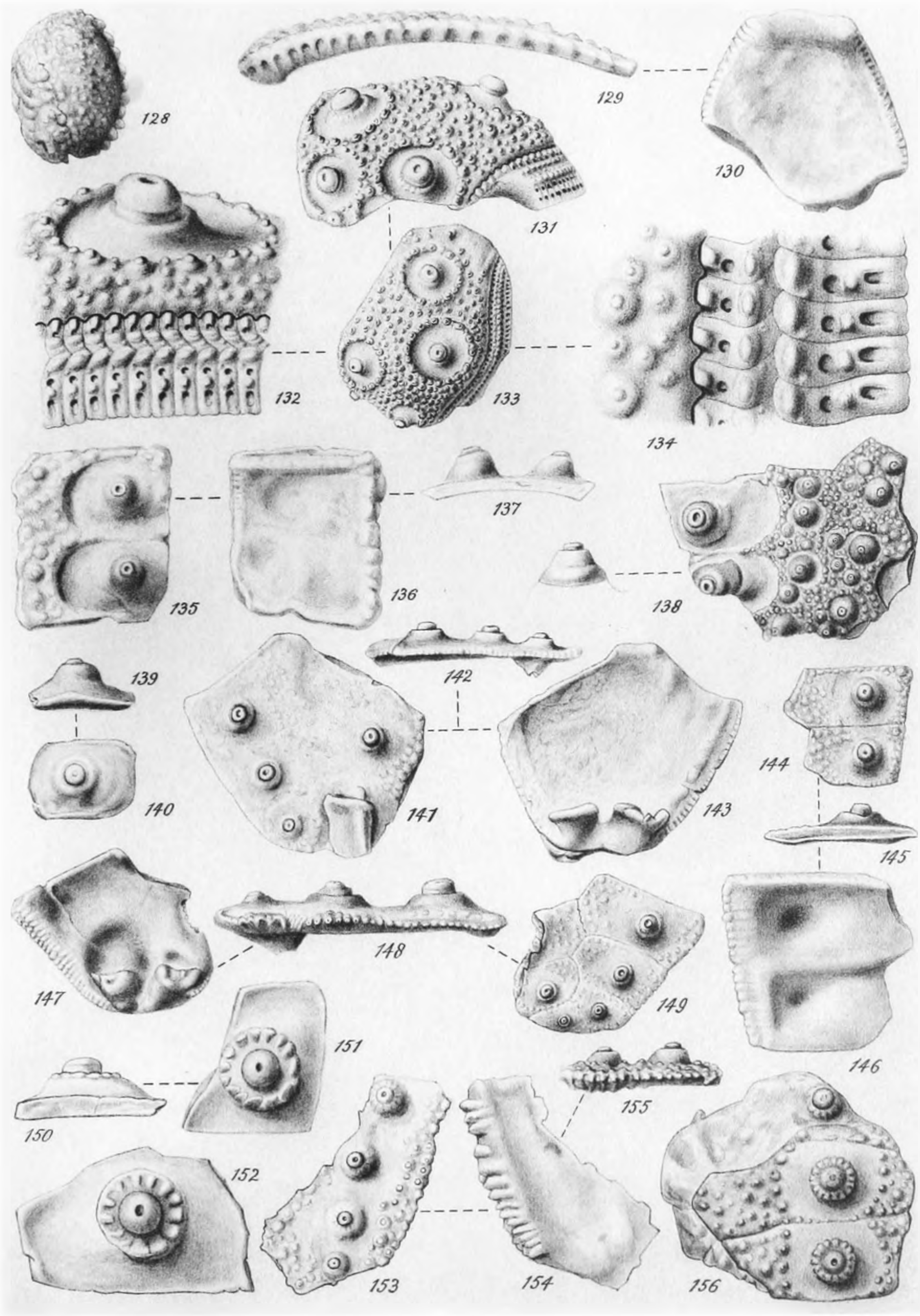
150. Specimen *b*, an interambulacral; side-view, showing the bevels of the transverse margins 89
151. Specimen *b*; external view. 89
152. Specimen *a*, an interambulacrum; external view 89

Miocidaris verrucosus.

(Figs. 153—156, all × 5 diam.'

153. Holotype, from Quarry near Cutting I, adoral fragment of an interambulacrum; external view 90
154. Holotype; internal view. 91
155. Holotype; side-view of part of the adradial margin, showing how it becomes more vertical towards the oral end 90, 91
156. Specimen *b*, portions of three interambulacrals on matrix . . . . 90—91

All figures drawn from nature by A. T. HOLLICK; but fig. 134 has been completed, under the Author's direction, by A. H. SEARLE, owing to Mr. HOLLICK's illness.



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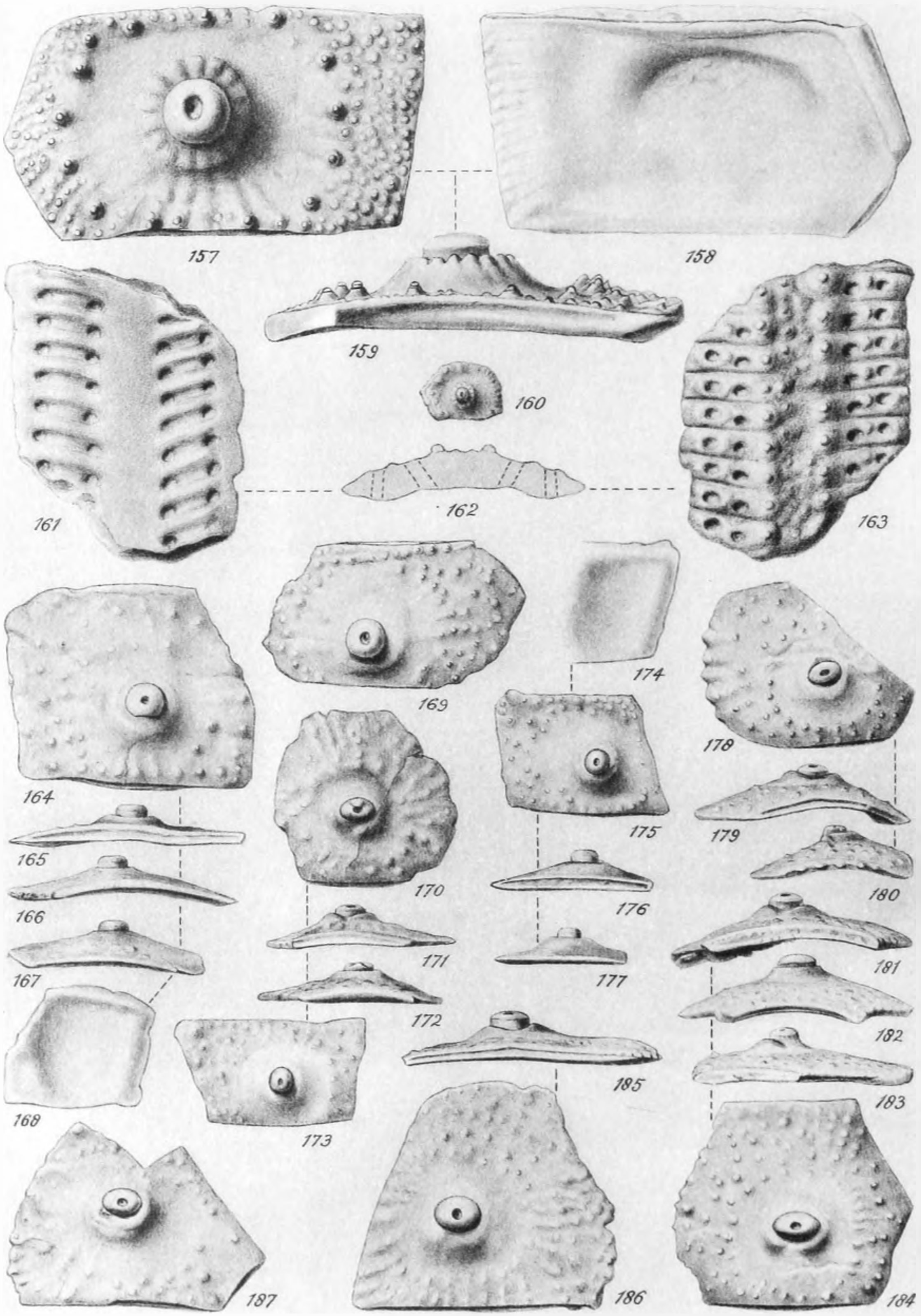
Tiarechinus, Triadocidaris, Miocidaris.



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Miocidaris, Anaulocidaris.

PLATE VII.

Miocidaris planus.

(Figs. 157—159, all × 5 diam.)

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157. Holotype, interambulacral plate from Jeruzsálemhegy; outer view, adapical margin uppermost 91
158. Holotype, inner view 91
159. Holotype, side-view, from adoral margin . . 91

Miocidaris sp. indet. γ.

160. Interambulacral plate from Cutting I, Veszprém—Jutas Railway, outer view, nat. size 92

Miocidaris sp. indet. δ.

(Figs. 161—163, all × 10 diam.)

161. Portion of an ambulacrum from Cserhát, inner view, with the adoral end lowermost . . 93
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163. The same, outer view 93

Anaulocidaris testudo.

Interambulacral plates only.

(Figs. 164—187, all × 5 diam., except fig. 168, × 3 diam.)

164. Specimen *a*, Jeruzsálemhegy; outer view . 95, 96
165. Specimen *a*, seen from adoral margin . . . 95
166. Specimen *a*. seen from adapical margin . . 95

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167. Specimen *a*, seen from the left (i. e. the adambulacral) margin 95
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170. Specimen *c*, » » » . . 96
171. Specimen *c*, from adoral margin 95
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175. Specimen *e*, outer view 95, 96
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177. Specimen *e*, from adapical margin 95
178. Specimen *f*, Jeruzsálemhegy; outer view . 95, 96
179. Specimen *f*, from adoral margin 95
180. Specimen *f*, from the left (i. e. the adambulacral) margin 96
181. Specimen *h*, Cutting I, Veszprém—Jutas Railway; from adoral margin 95
182. Specimen *h*, from adapical margin 95
183. Specimen *h*, from the right (i. e. the perradial) margin 95
184. Specimen *h*, outer view 95, 96
185. Specimen *j*, Cutting I, Veszprém—Jutas Railway; from adoral margin 95
186. Specimen *j*, outer view 96
187. Specimen *k*, Cutting I, Veszprém—Jutas Railway; outer view 95, 96

All figures drawn from nature by A. T. Hollick.
The process of reproduction has intensified the miliaries in figures 164—184; they are by no means so conspicuous in the specimens.

PLATE VIII.

Plegiocidaris ? sp. indet.

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188. Interambulacral plate, from Cserhát; outer view, × 5 diam. 99
189. The same; side-view, × 5 diam. 99

Eodiadema ? sp. indet.

190. Portion of an interambulacrum, from Cserhát; outer view, × 5 diam. 102
191. The same; top left-hand quarter of the preceding figure, × 10 diam. 102

Mesodiadema margaritatum.

192. Specimen *b*, adoral portion of an interambulacrum, from Cutting I on Veszprém—Jutas Railway; outer view, × 3 diam. 118
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197. Holotype; inner view, × 3 diam. . . 117, 118

Mesodiadema latum.

(Figs. 198—211, all × 10 diam.)

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199. Specimen *e*, an interambulacral of column *a*, Jeruzsálemhegy; outer view, adapical margin uppermost 120

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200. Specimen *e*, inner view, adapical margin uppermost 121
201. Specimen *b*, an interambulacral of column *a*, from Jeruzsálemhegy; outer view, adapical margin uppermost 119, 121
202. Specimen *g*, an interambulacral of column *b*, from Jeruzsálemhegy; inner view, adapical margin uppermost 120, 121
203. Specimen *f*, an interambulacral of column *a*, from Jeruzsálemhegy; outer view, adapical margin uppermost 119, 121
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206. Holotype: inner view, adapical margin uppermost 121
207. Holotype; outer view, adapical margin uppermost 119, 121
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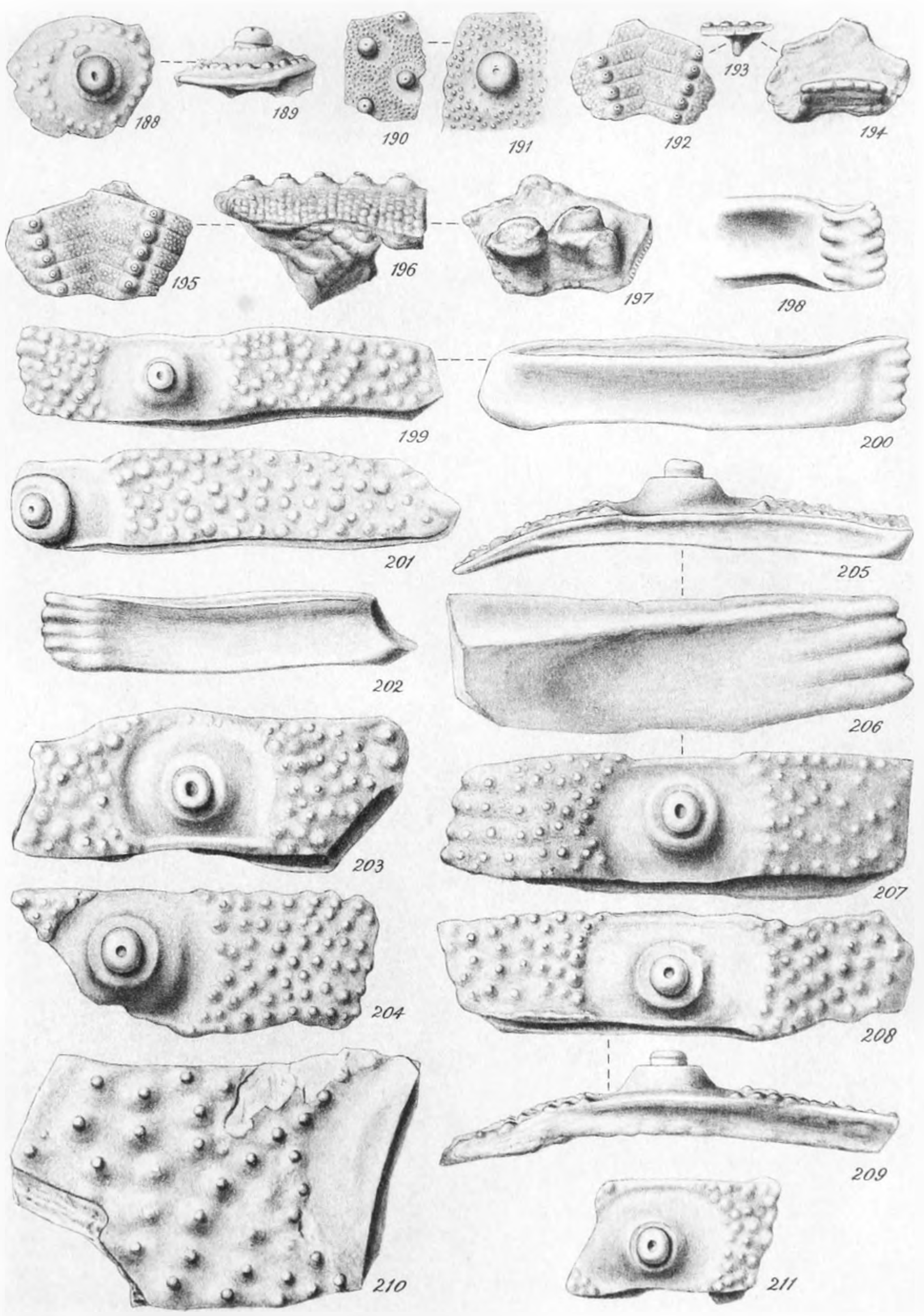
211. Specimen *x*, an interambulacral, Cserhát; outer view, adapical margin uppermost. . . 122

All figures drawn from nature by A. T. Hollick.

BATHER: Bakony Trias Echinoderms. PLATE VIII.



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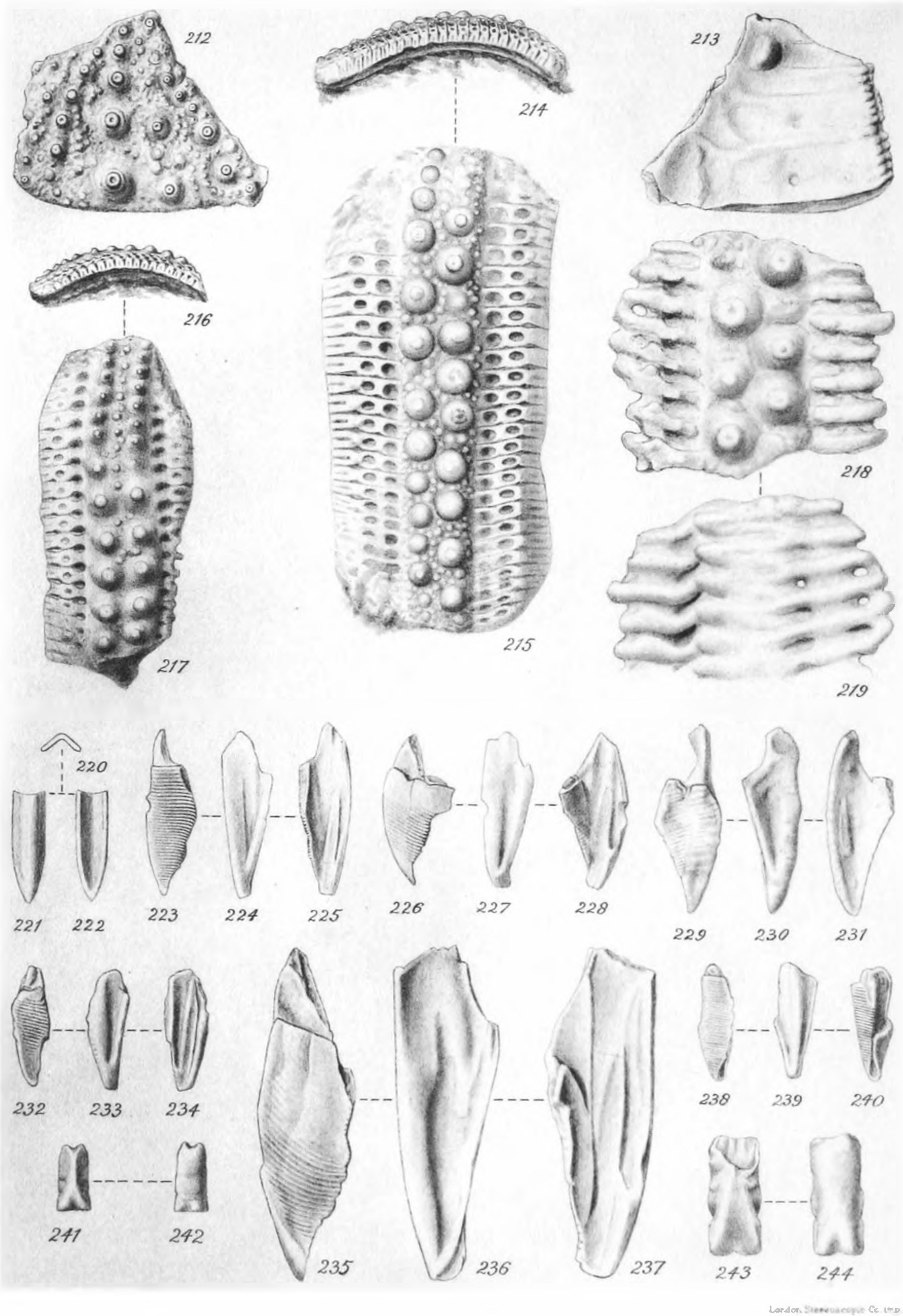
Tiarechinus, Triadocidaris, Miocidaris



Diademopsis, Ambulacra, Oris armatura.

PLATE IX.

Hemipedina (Diademopsis) incipiens.

Diadematoid ambulacrum α.

Diadematoid ambulacrum β.

Diadematoid ambulacrum γ.

Remains of the Jaw-apparatus.

(Figs. 220—244, all × 3 diam.)

(In figures 241—244 the exterior or condylar end is uppermost)

All figures drawn from nature by A. T. HOLLICK.

PLATE X.

Anaulocidaris.

(The specimens of *A. Buchi* are from St. Cassian, those of *A. testudo* are fróm Jeruzsálemhegy. All figures on this plate are enlarged 3 diameters.)

A. Buchi.

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245. **MM, g.** Radiolus trulliformis, handle and part of blade	162
246. **MM, d.** Heautotype, MÜNSTER, 1841, pl. iii, f. 11. Radiolus spatuliformis, adapical face, cf. text-fig. 37. .	158, 161
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250. Radiolus spatuliformis from Cardita Schichten, Haller Salzberg, in Pal. Mus. München, provisionally referred to this species; adoral face	168, 169
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254. **BM, m.** Side-view	167
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A. testudo.

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258. The same, adoral face	141—143
259 Radiolus remiformis *b*, adapical face. Cf. text-fig. 12	141. 143
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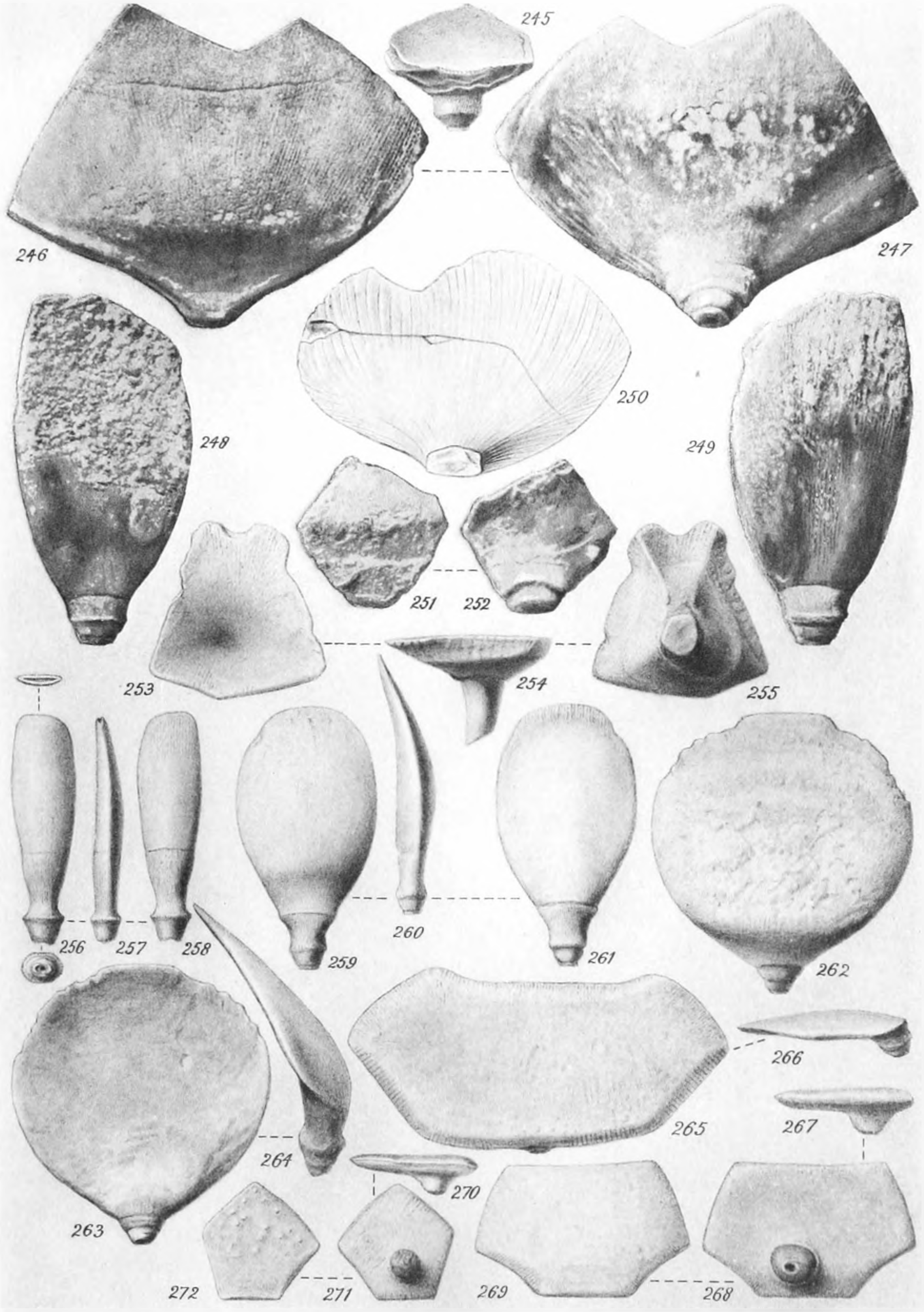
Figures 246, 247, 248, 249, 251, 252, 258, 261, 263, 268, and 271 are either reproduced from, or based on, photographs. Figure 250 is from a sketch by the Author.

All other figures are drawn from nature by A. T. HOLLICK.



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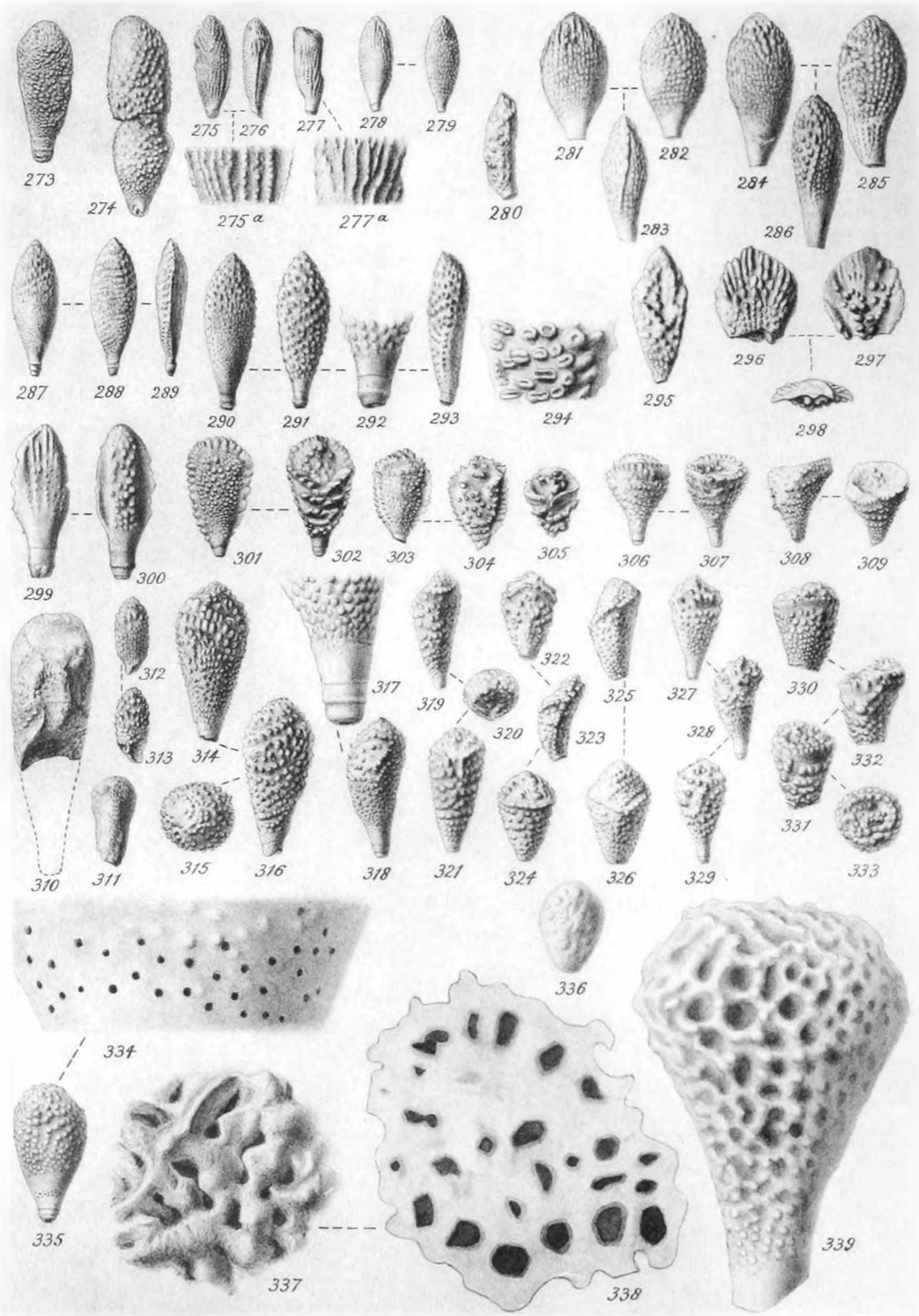
Anaulocidaris.



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Radioli.

PLATE XI.

(All figures are natural size except where otherwise stated.)

«*Cidaris*» *alata typica*.

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273. Holotype, from Agassiz' cast X, 23 in Brit. Mus.; adapical face 175
274. Specimen *a*, from Cserhát; adapical face . . 175

«*Cidaris*» *alata subalata*.

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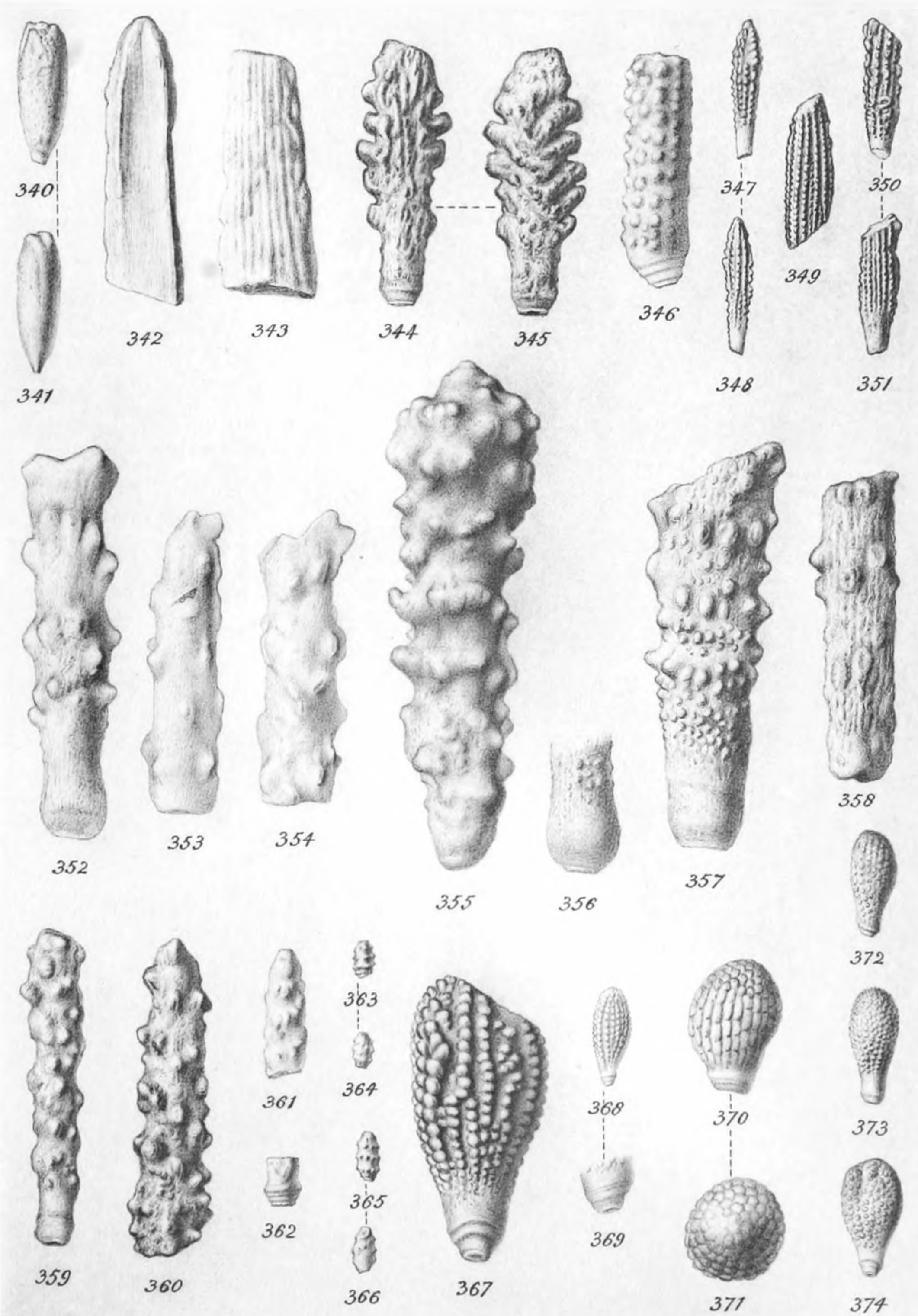

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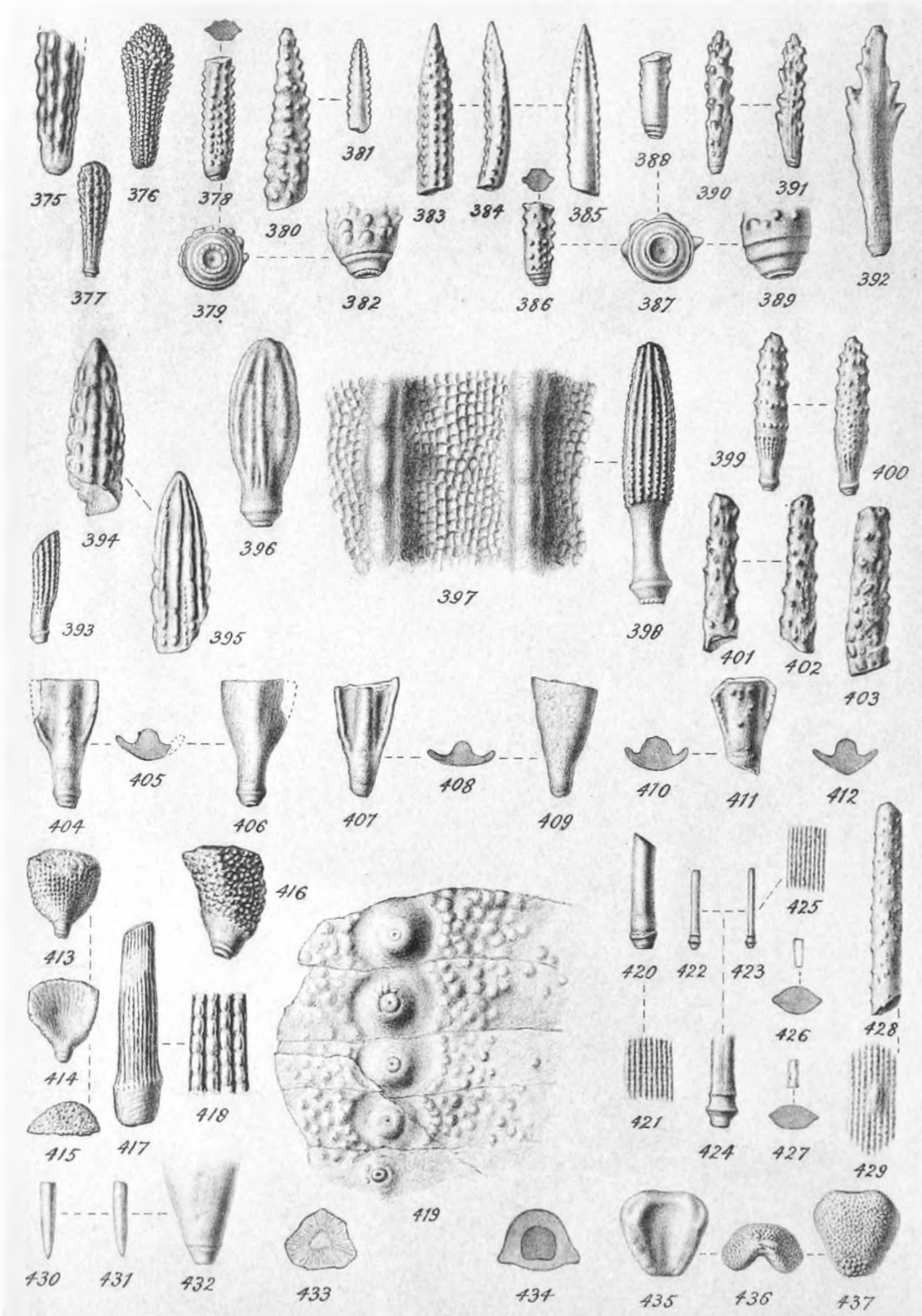
Radioli.



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Radioli, Mesodiadema, Asteroidea.

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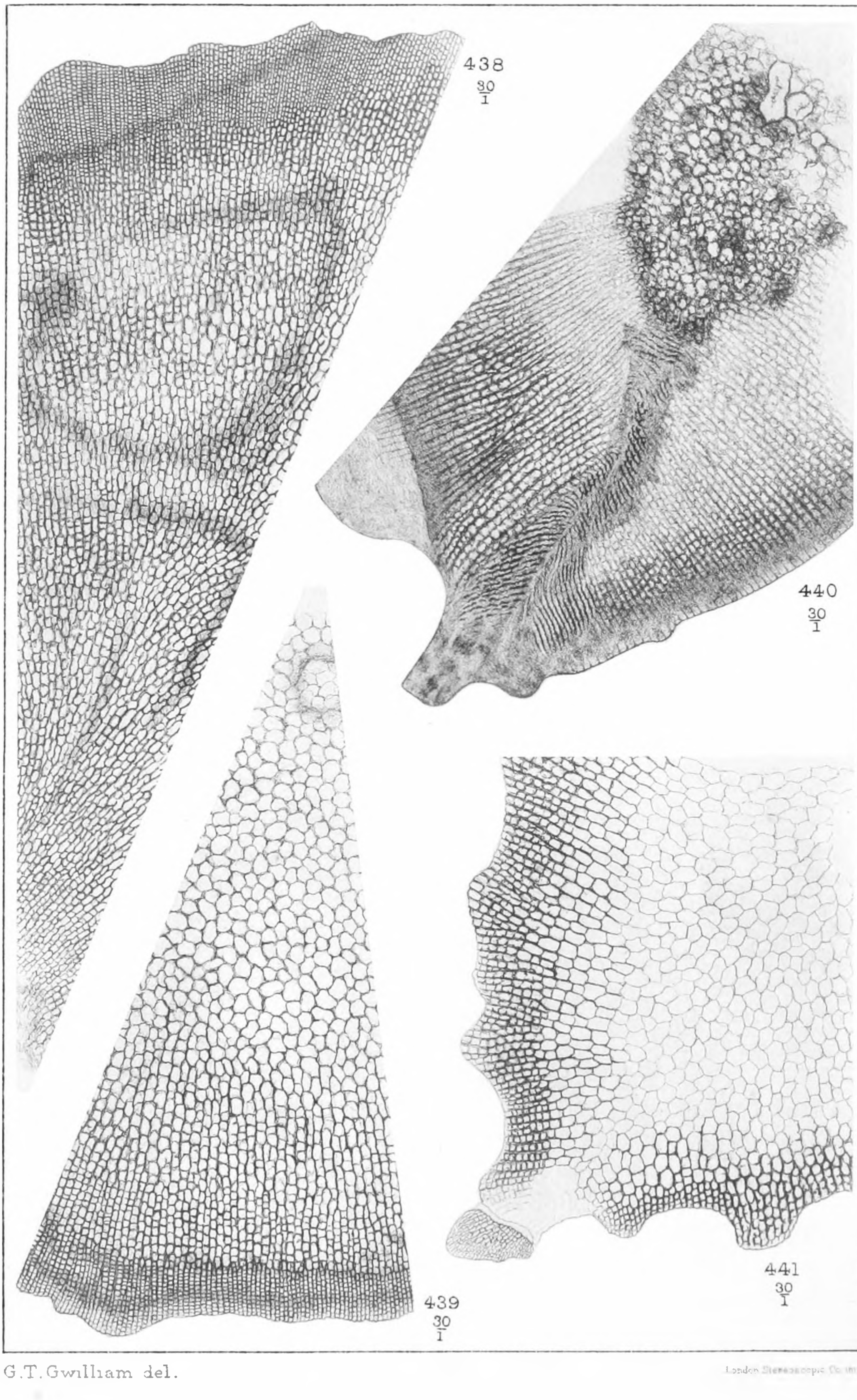
All the figures were drawn from the sections by G. T. Gwilliam, under the Author's direction, at a magnification of 40 diam., and were reduced by photography to the present scale.



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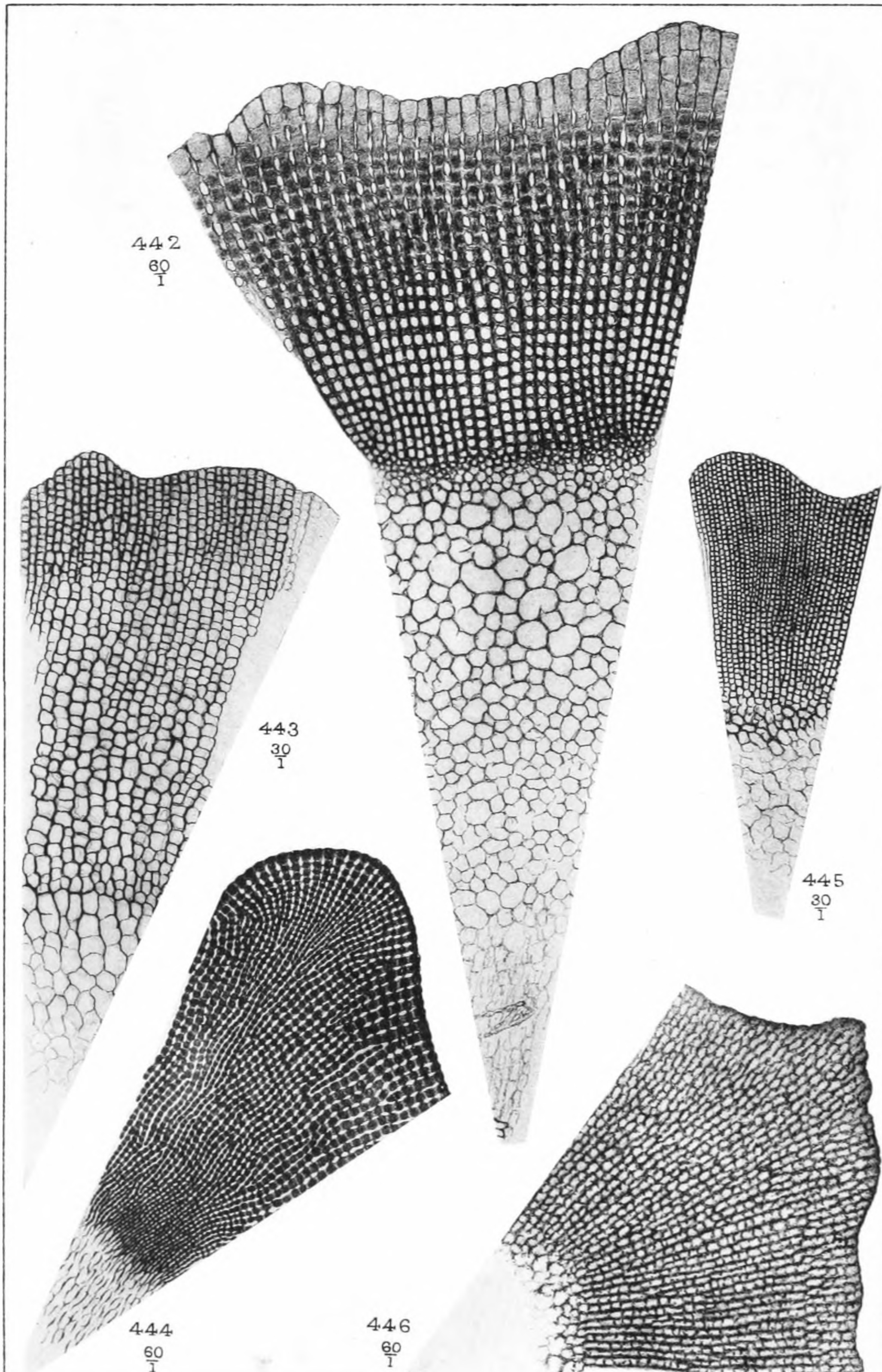

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All the figures were drawn from the sections by G. T. GWILLIAM, under the Author's direction, at a magnification of 80 and 40 diameters respectively, and were reduced by photography to the present scale.

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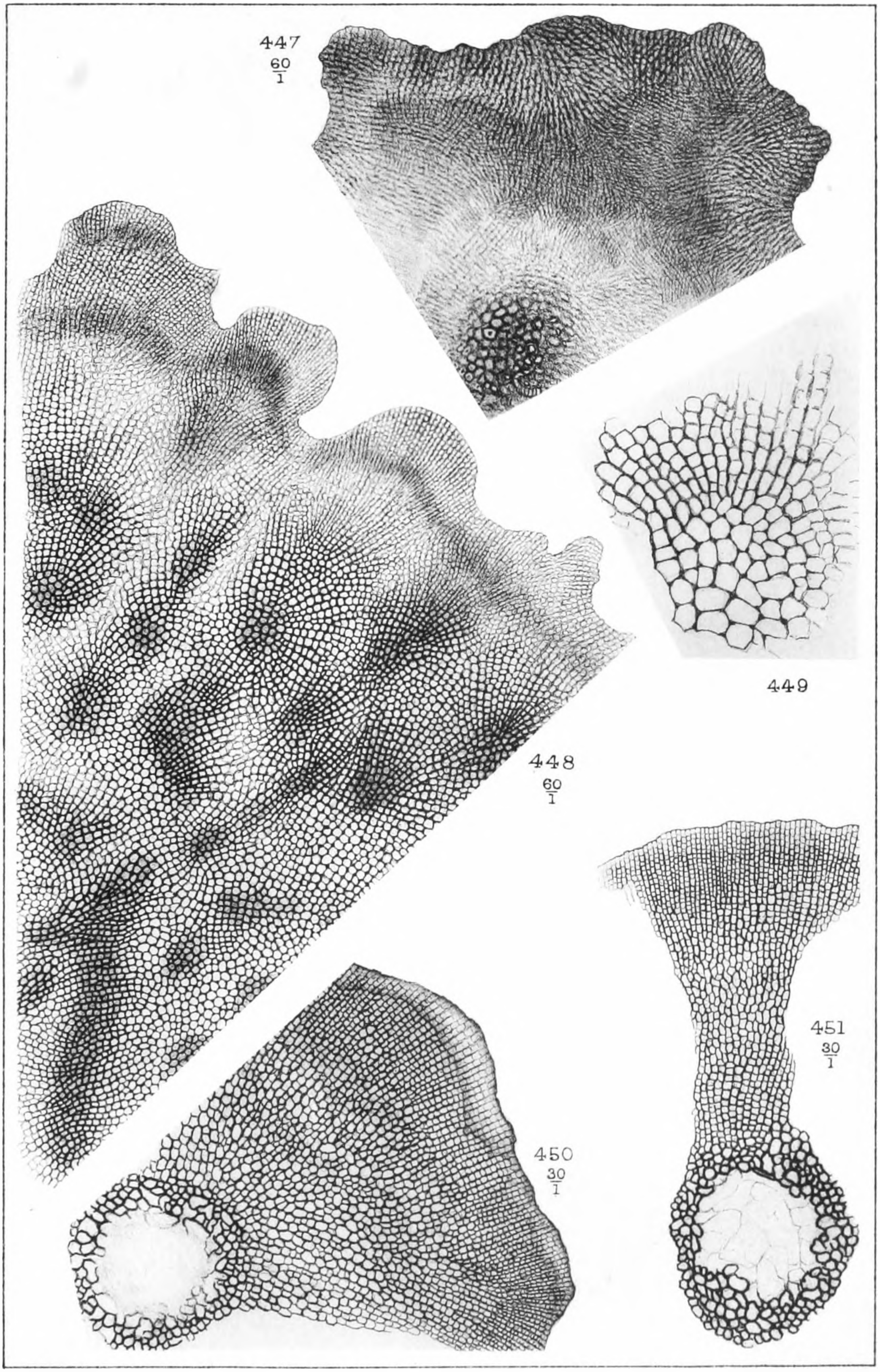
All figures were drawn from the sections by G. T. GWILLIAM, under the Author's direction, at a magnification of 240, 80, and 40 diameters respectively, and were reduced by photography to the present scale.



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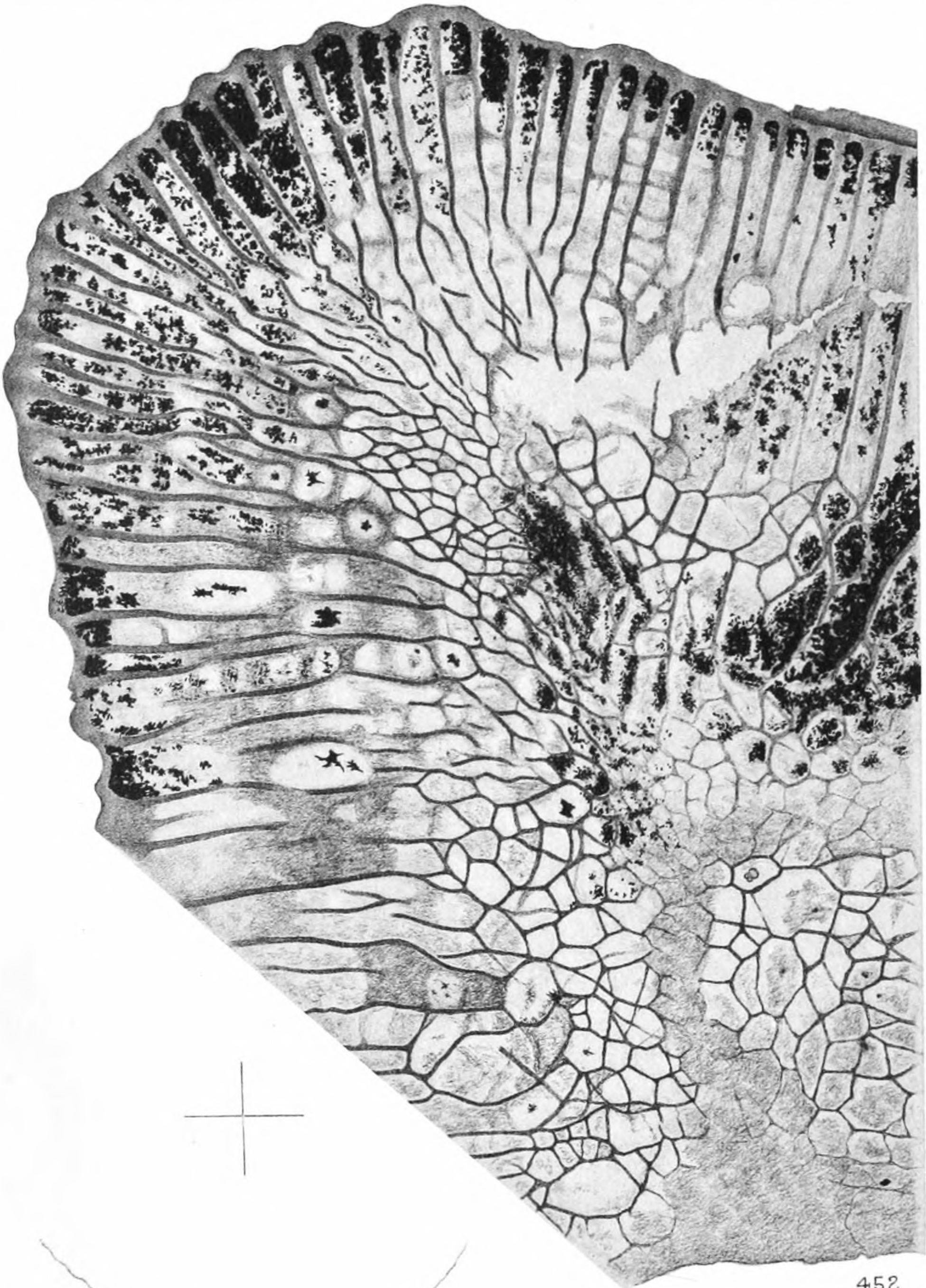

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All figures were drawn from the sections by G. T. Gwilliam, under the Author's direction, at a magnification of 80 and 40 diameters, respectively, and were reduced by photography to the present scale.

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All figures were drawn from the sections by G. T. GWILLIAM, under the Author's direction, at a magnification of 120 and 40 diameters respectively, and were reduced by photography to the present scale.

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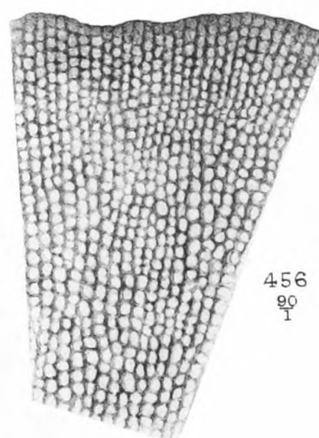

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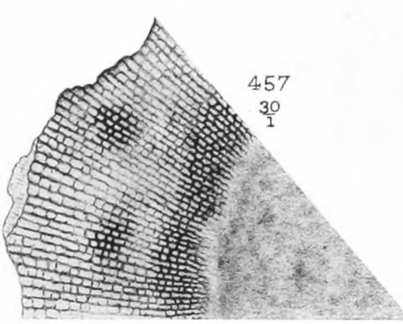

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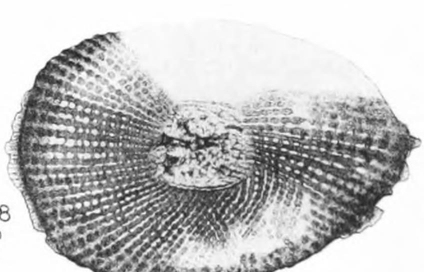

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